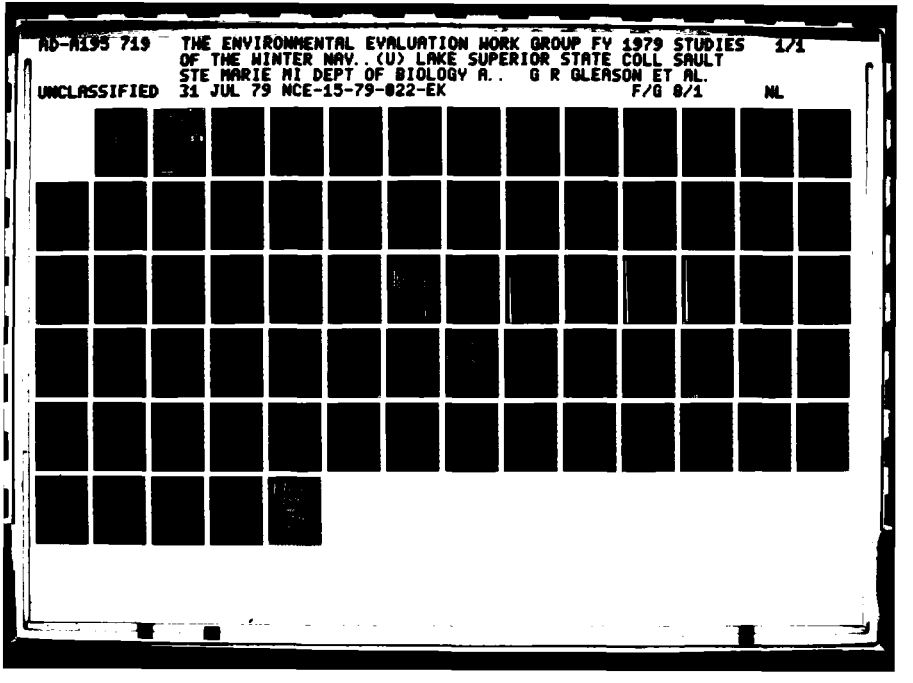
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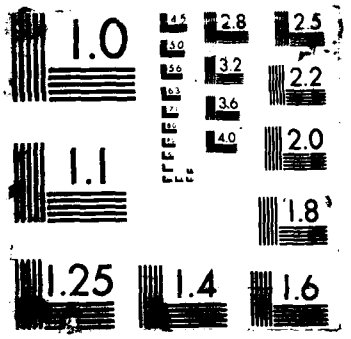
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THE ENVIRONMENTAL EVALUATION WORK GROUP FY 1979 STUDIES OF THE WINTER NAVIGATION DEMONSTRATION PROGRAM

EVALUATION OF BENTHIC DISLOCATION DUE TO PRESSURE WAVES INITIATED BY VESSEL PASSAGE IN THE ST. MARYS RIVER

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July 31, 1979

This study was conducted as part of Project Number 5100 of the Great Lakes Basin Commission for the Environmental Evaluation Work Group of the Winter Navigation Board. Funding was provided by the U. S. Army Corps of Engineers - Detroit District through the Great Lakes Basin Commission.

Project Officer

David A. Gregorka
Great Lakes Basin Commission
3475 Plymouth Road
Ann Arbor, Michigan 48106

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Shipping through ice creates pressure waves. Pressure waves can displace benthos. The object of this study was to determine if through 'hinge' cracks in the ice the quantitative and qualitative loss was significant to the total estimated benthic population at three St. Marys River sites sampled between January 26 and March 27, 1979.

Benthic displacement was associated with vessel length, speed, channel distance, bottom contours of the river, ice thickness and benthic density. The study found that approximately 0.1% of the benthic population below the ice was displaced and concluded that at Coast Guard regulated vessel speed limits, little damage would occur to existing benthic populations as a result of displacement through surface ice 'hinge' cracks.

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Valuable assistance was also contributed by the United States Coast Guard in the form of an electrical source at the Adams' sample station and vessel traffic information throughout the study. The task of identifying benthic invertebrates was greatly eased with the willing assistance of Jarl Hiltunen from the Great Lakes Fisheries Research Lab in Ann Arbor.

ABSTRACT

Ships navigating ice covered connecting channels in the Upper Great Lakes frequently reach a critical speed which creates a pressure fracture line near the shore. The sudden pressure release due to the fracture displaces water, sediments and incumbent benthos to the ice surface. The object of this study was to determine if the loss and environmental disruption was significant to the total estimated benthic population at selected sites in the St. Mary's River.

Three stations established on the St. Mary's River between Frechette (NE¼ Sec. 22, T47N, R1E) and Six Mile Points (SE¼ Sec. 26, T47N, R1E) were sampled during the winter of 1978-79. Sampling paramaters included benthic, ice surface deposits and ice movement due to vessel passage. Twenty-four ships monitored provided 11 samples of which 5 contained benthic organisms.

SUMMARY

The 1978-79 extended shipping season did not produce a significant loss of benthos to the ice surface. It was found that for a one meter length of crack approximately 10 organisms were displaced per vessel passage, or 0.1% of the existing benthic population below the sample sites.

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OBJECTIVES

It has been noted that there is sediment deposition to surface ice through fracture lines that develop as a result of vessel movement through ice fields. This study was undertaken in an attempt to determine quantitatively and qualitatively the possible loss of benthos associated with this loss of sediment to surface ice.

Three near shore sites known to be affected by the pressure wave effect were chosen as sample locations for the study. Benthic displacement was evaluated in correlation with vessel length and speed and also the bottom contour and the distance from the channel the displacement occurs. Other experimental considerations include ice thickness, time or date, and the original benthic density, all of which may be important in determining the significance of the benthic displacement.

INTRODUCTION

Previous Observations: On January 25, 1978, a group from the environmental section of the United States Corps of Engineers and representatives from the United States Fish and Wildlife Service met in Sault Ste. Marie, Michigan to witness firsthand the type of action that takes place in the ice field during vessel passages. These observations were later further substantiated by a group from CRREL that was working at Nine Mile Point, Sugar Island. It was the information gained from these observations that eventually led to the present research in benthic displacement with respect to winter vessel traffic.

Identified Zones of Concern: The identified zones of concern for this study all lie along the St. Mary's River between Three Mile Road and the North Neebish Channel. Zone 1 runs from Three Mile Road to Nine Mile Road along the mainland shore of the river. Zone 2 is at Nine Mile Point on Sugar Island and Zone 3 being the North Neebish Channel. These zones, as well as the actual sample site selections, were a concurrence of the contractors, i.e. the Great Lakes Fishery Research Laboratory (GLFL) and the Cold Regions Research and Experimental Laboratory (CRREL).

METHODOLOGY

Three sample sites were chosen along the mainland side of the St. Mary's River between Three and Five Mile Roads (Figure 1). Site No. 1 (Riverview) was located at Riverview Marina approximately 6 meters off shore. Site No. 2 (Doran's) was in front of Dr. Gleason's home near Four Mile Road, approximately 1 meter off shore. Site No. 3 (Adam's) was one-half mile upstream from Six Mile Point, about 8 meters from shore. Location of the benthic surface sampling apparatus was dictated by the presence and position of pressure wave induced fracture lines (Figure 2 - 7).

In order to correctly evaluate the benthic displacement data other parameters that were closely linked to it had to be monitored and measured as well. One of these paramaters being the pressure wave associated with vessel passage. The apparatus for recording these pressure waves was developed and constructed at the Lake Superior State College Aquatics Research Laboratory (Figure 8). A 3/4 inch iron rod ran through a hole in the ice and was embedded about 2 feet into the bottom. To this a writing instrument was attached on an arm of spring steel (to keep constant pressure against the recording drum). The recording was made using a modified Bird-type kymograph which was free to move with the ice sheet. A timer automatically ran the kymograph for a 12 minute (usually) interval during vessel passage.

It was found necessary to place a coil of heating cable around the inside of a 2 foot length of 6 inch diameter aluminum pipe and then place

this into the hole surrounding the iron pipe. This was to prevent the hole from freezing up around the iron pipe and thus causing it to move with the ice sheet. A heat lamp was on constantly to help keep the equipment functioning properly despite the extremely cold conditions. All equipment was housed in a 4 foot by 4 foot portable canvas ice fishing shanty.

Following vessel passage recordings were properly calibrated by time (minutes) and vertical ice movement (centimeters). Titles and important observations were also recorded on the charts at this time.

The apparatus for ice surface sampling of displaced benthos was also developed at the Lake Superior State College Aquatics Research Lab (Figure 9). This basically consisted of a large plastic bag that was attached to a wooden frame. The frames were rectangular and enclosed on the top and both sides leaving the bottom and both ends open. These frames were constructed in three different sizes on the basis of frame mouth width. The three mouth widths used were 8, 10, and 16 cm respectively. From this point on, the ice surface benthic samplers will be referred to as simply benthic samplers.

After randomly locating the sample site along a 100 foot stretch of the fracture line the benthic samplers were set up as follows. A large depression was chipped out approximately 15 cm from the crack. The wooden sampler frame was then placed perpendicular to the crack such that it rested at the edge of the depression and extended slightly over the edge of the crack. Two wire test tube racks were then placed

Methodology (Continued)

in the collecting bag to keep accumulating snow from collapsing the bag and preventing displaced water from entering. The bag was then carefully placed into the depression and its mouth then attached to the frame by a strong rubber band. Slush was packed along the side of the frame as a sealant to insure that all displaced water entering the frame mouth would be funnelled into the collecting bag. The benthic samplers were found to effectively collect about 90 to 95 percent of the displaced water.

Immediately following vessel passage the samplers were checked to see if a sample had been obtained. Those containing samples were placed in a second bag and taken to the laboratory for later study. Empty samplers were collected.

At the lab samples were filtered through a suction filter and the volume of water was then measured and recorded. Filter papers were then scanned under a dissecting scope (15x magnification) for any benthic organisms present. Organisms found were placed in 10 percent formalin and later were keyed and identified.

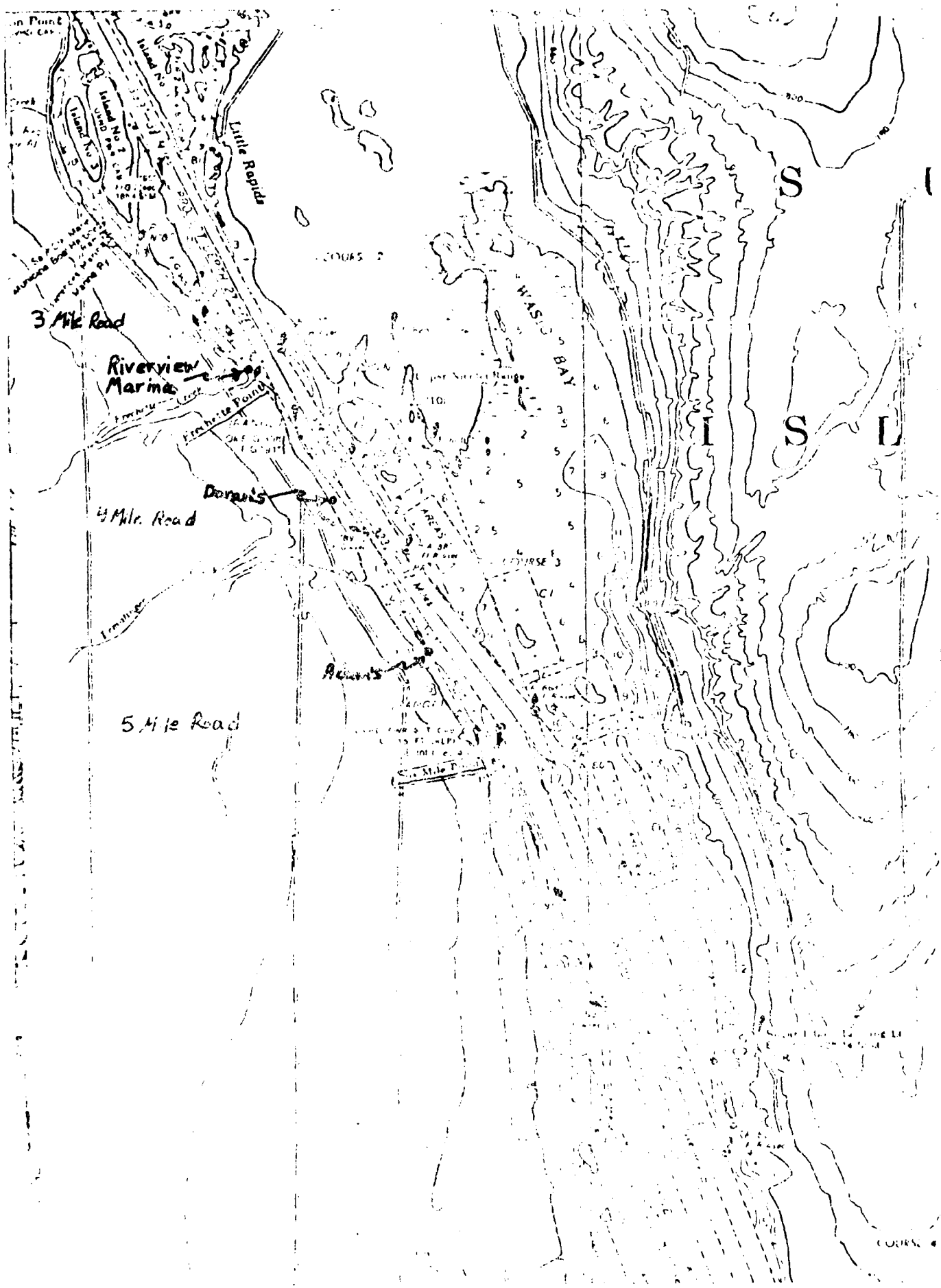
Bottom samples were taken at all sample locations in order to form a basis of comparison for evaluating later benthic displacement data. Riverview was sampled on January 24, Doran's on January 25, and Adam's on February 15.

A "Jiffy" power auger was used to drill four holes approximating the corners of a four foot square. The ice in between was spuded out and the freed chunk removed. Three samples were then taken from a four foot square area. An Ekman bottom dredge was used to obtain the samples.

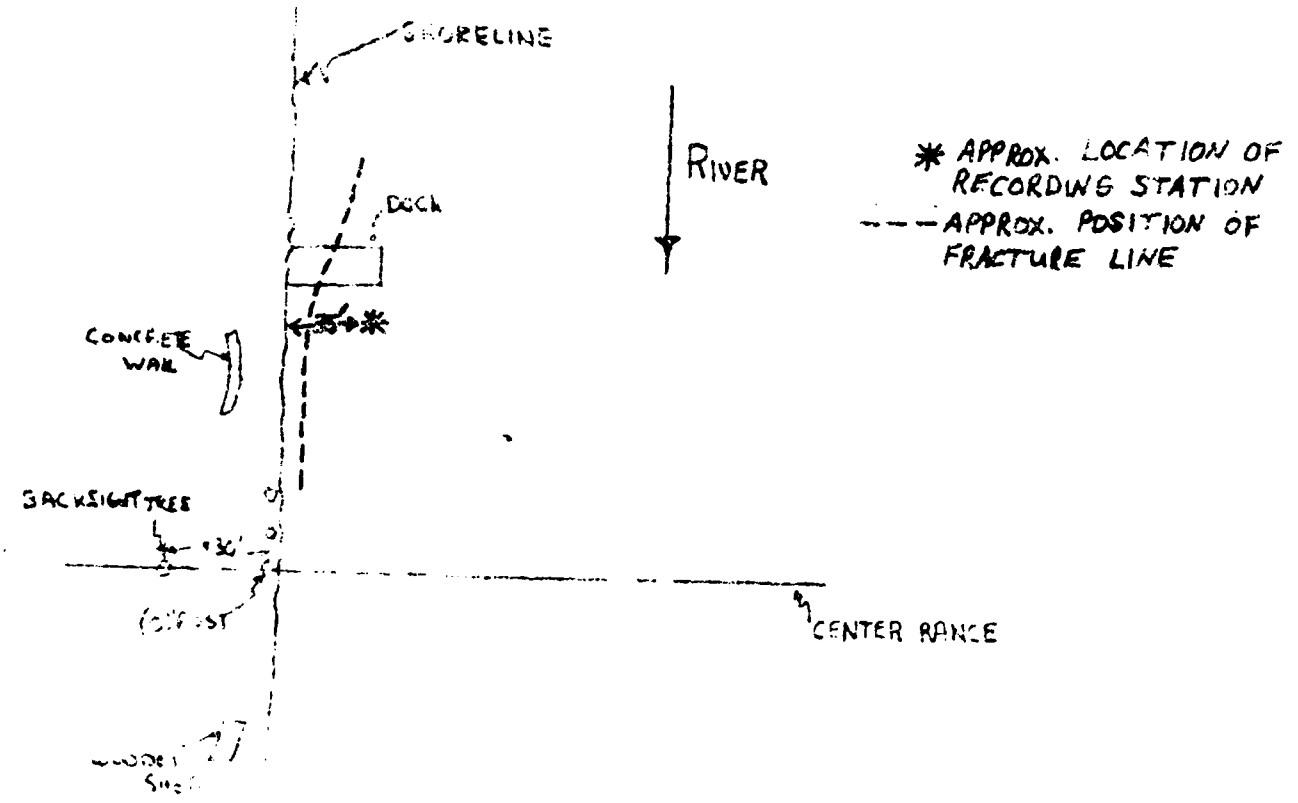
Methodology (Continued)

Samples were rinsed free of mud and sediments and placed into jars. Organisms were later identified, counted and recorded. Specimens were preserved in 10 percent formalin solutions.

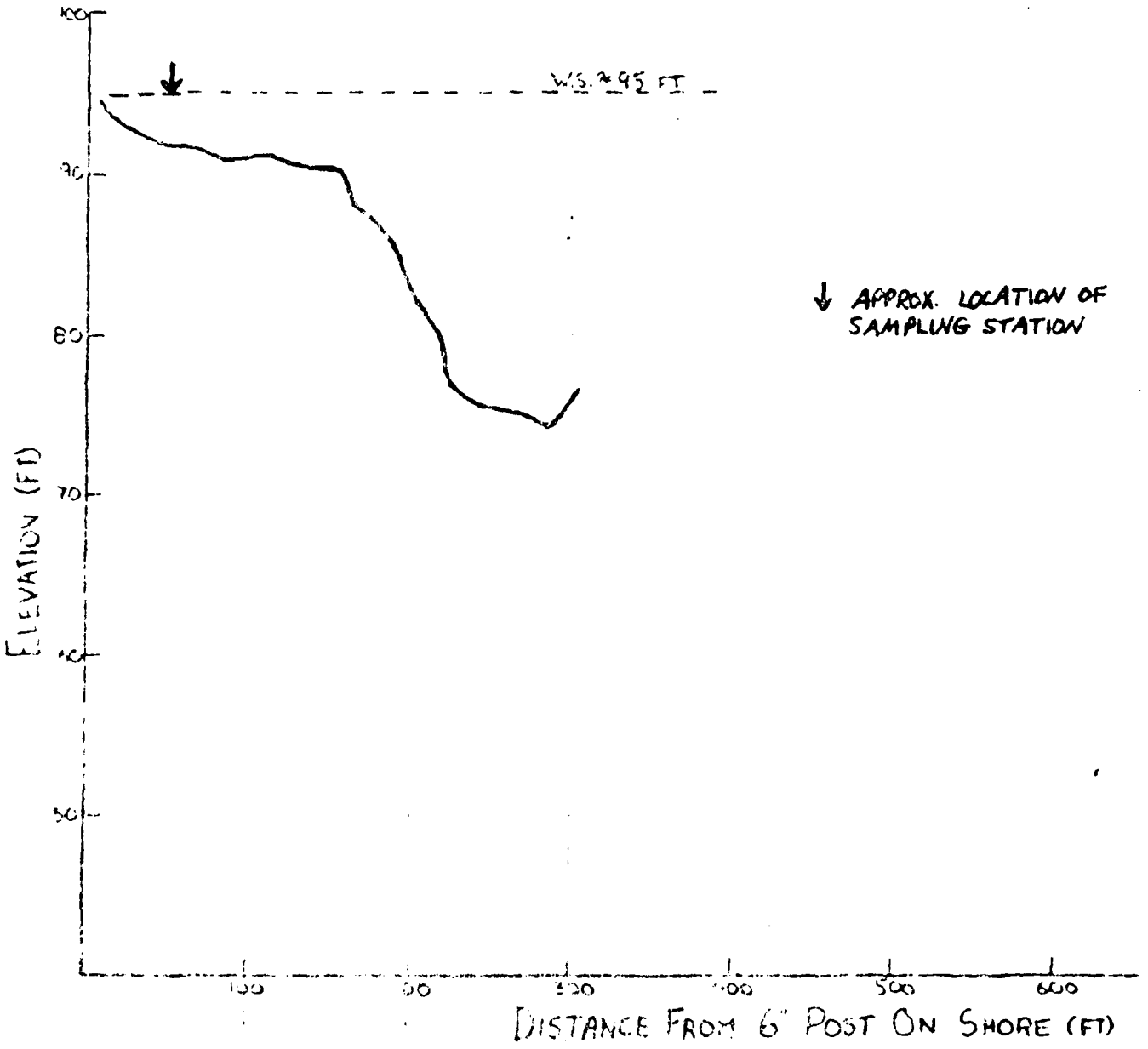
SAMPLE SITE LOCATIONS
Figure 1



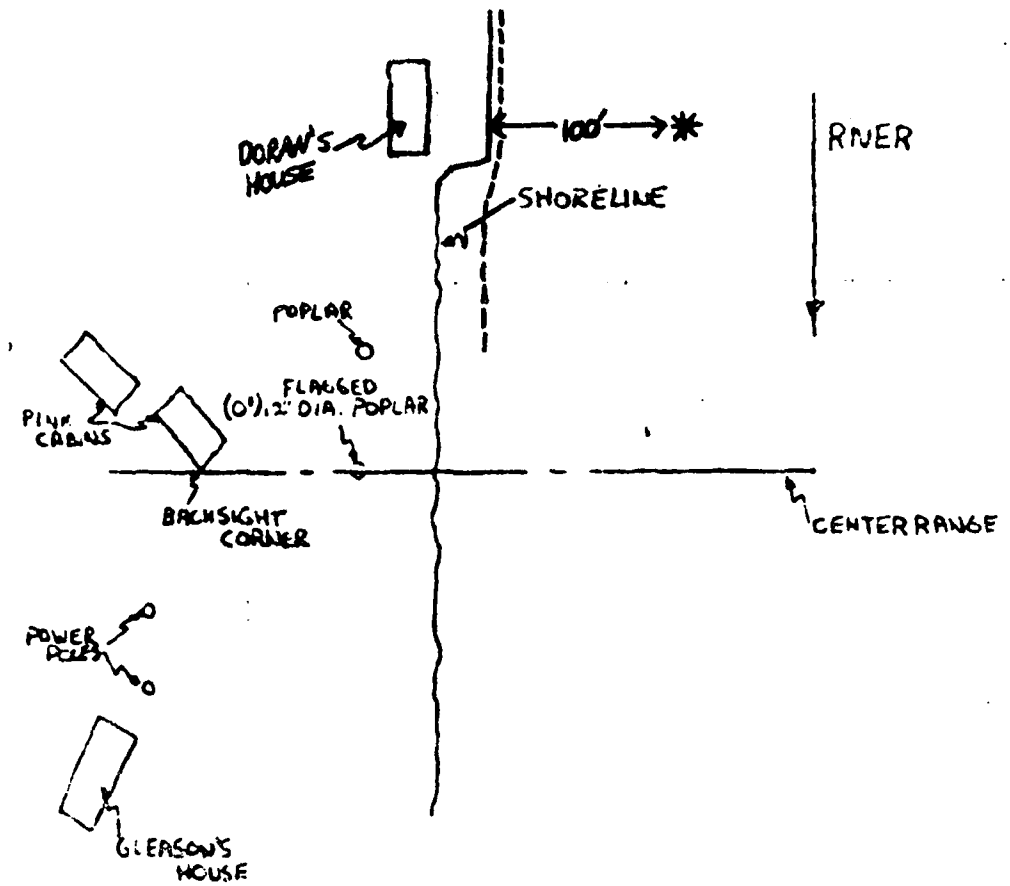
RIVERVIEW CENTER RANGE
Figure 2



RIVERVIEW CENTER RANGE PROFILE
Figure 3

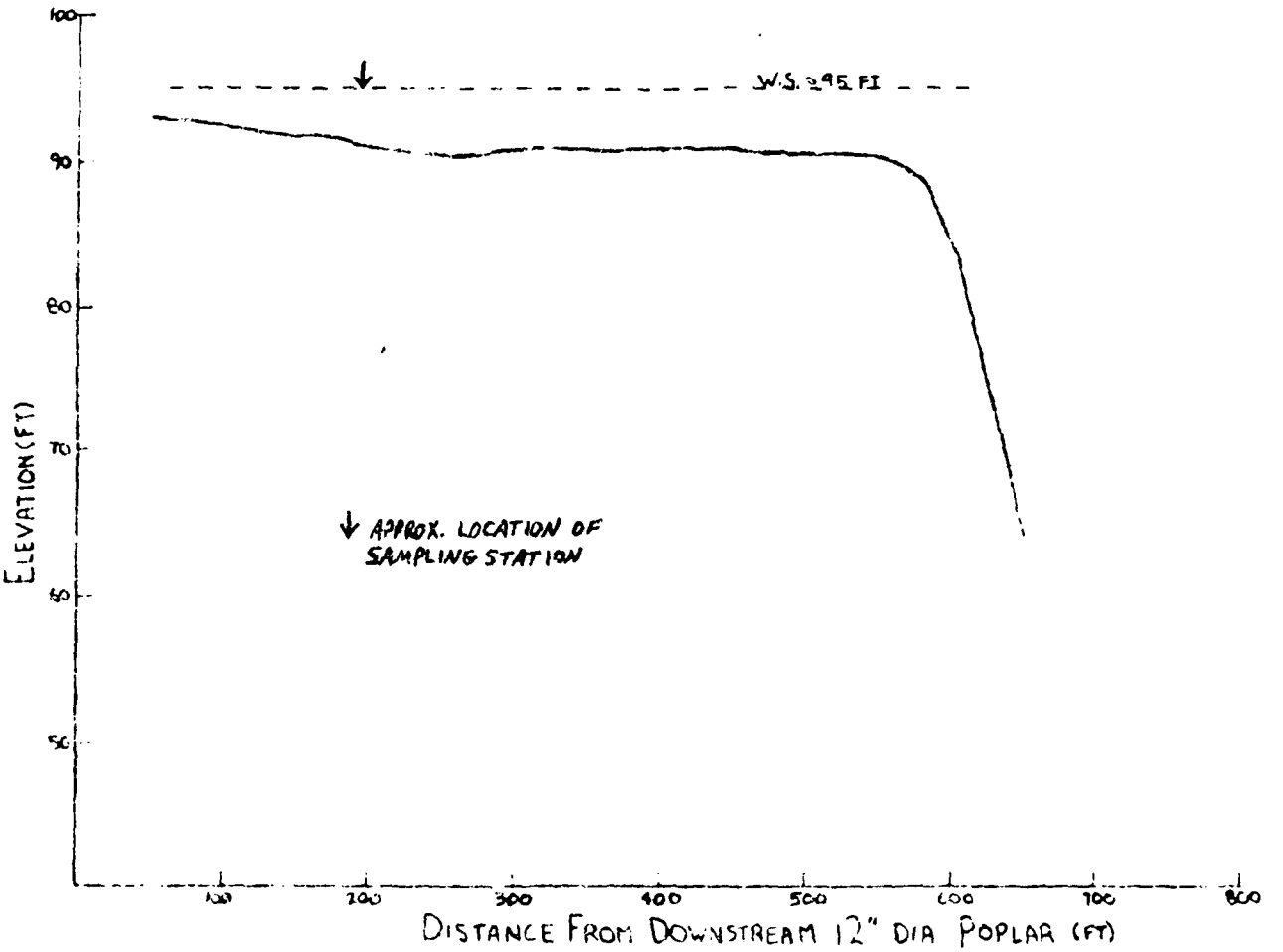


DORAN'S CENTER RANGE
Figure 4

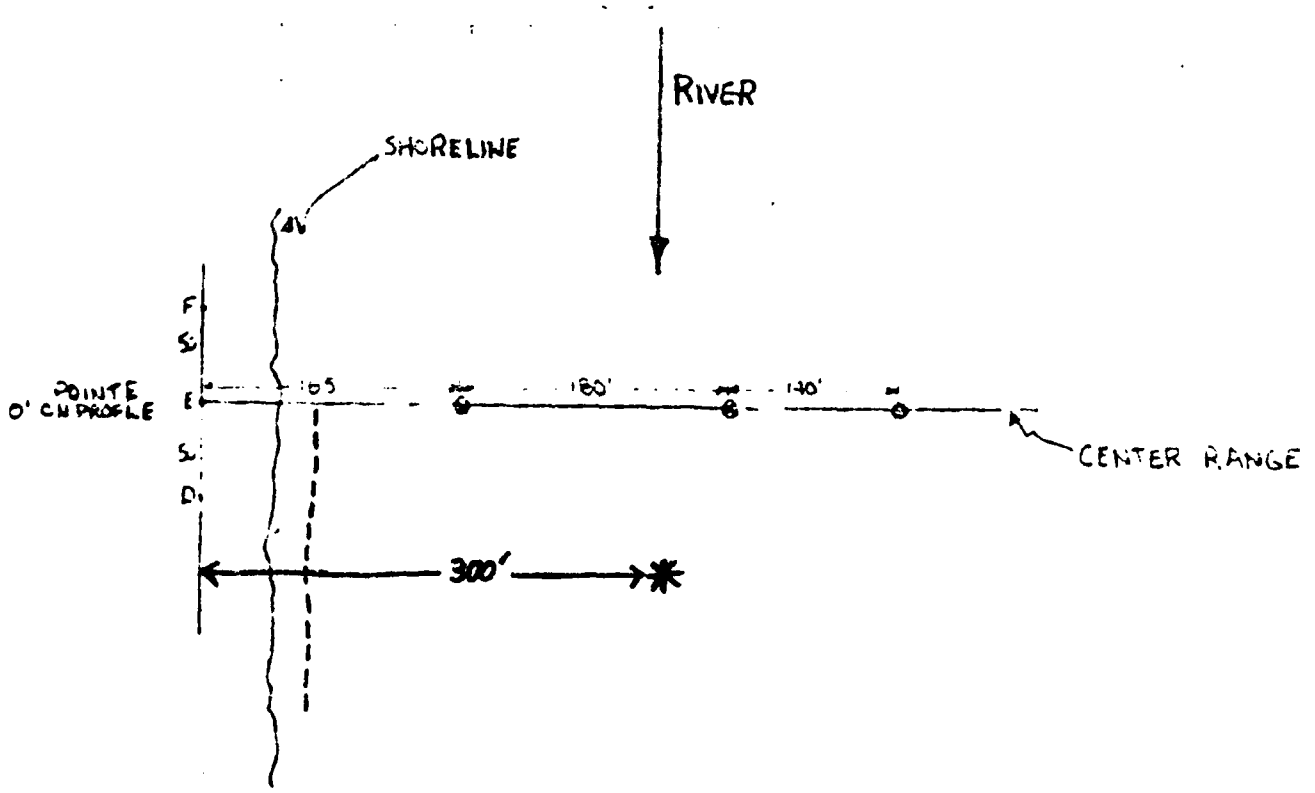


* APPROX. LOCATION OF RECORDING STATION
---APPROX. POSITION OF FRACTURE LINE

DORAN'S CENTER RANGE PROFILE
Figure 5



ADAM'S CENTER RANGE
Figure 6

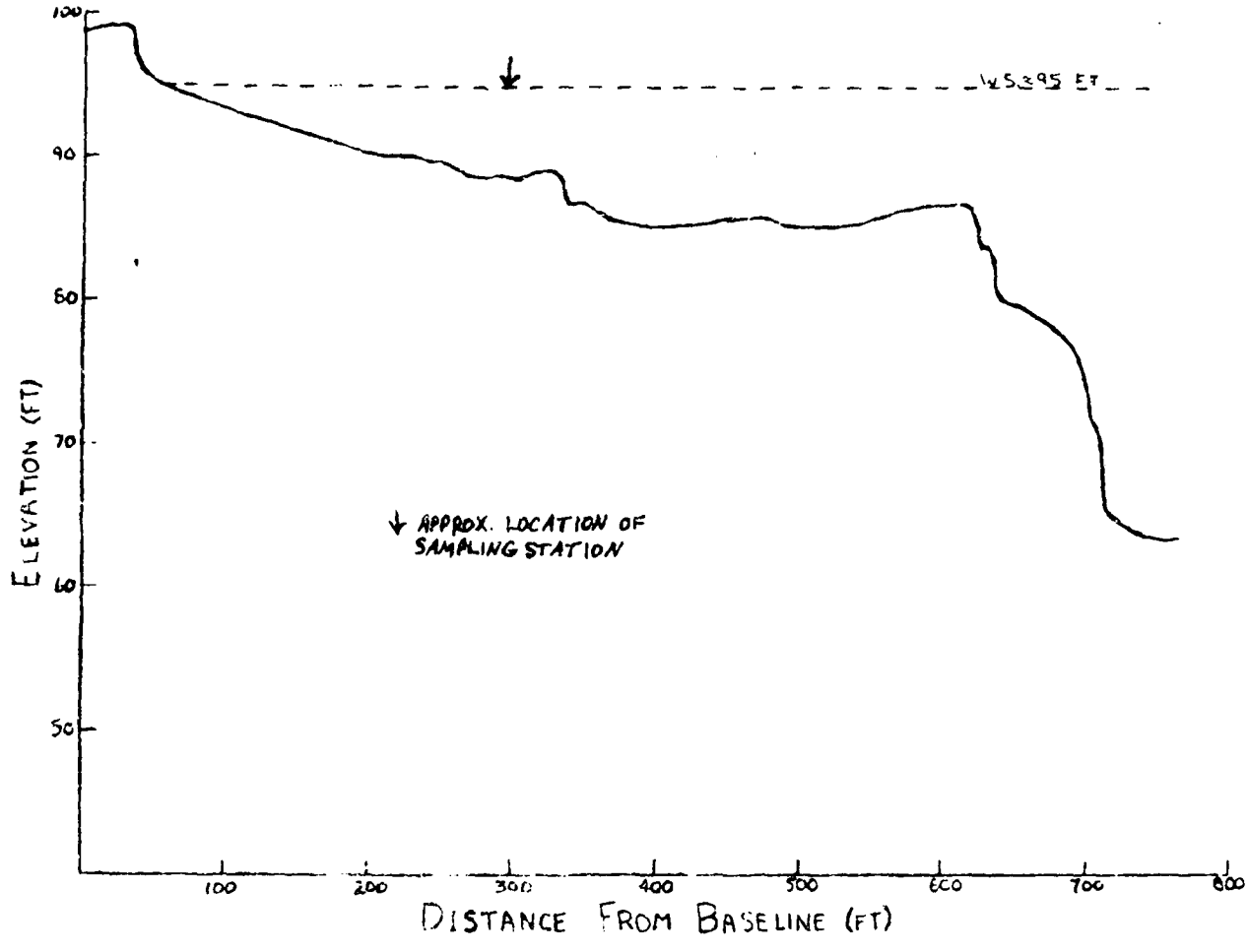


⊗ APPROX. LOCATION OF BENTHIC SAMPLING

✱ APPROX. LOCATION OF RECORDING STATION

– – – APPROX. POSITION OF FRACTURE LINE

ADAM'S CENTER RANGE PROFILE
Figure 7



VESSEL PRESSURE WAVE RECORDING APPARATUS
Figure 8

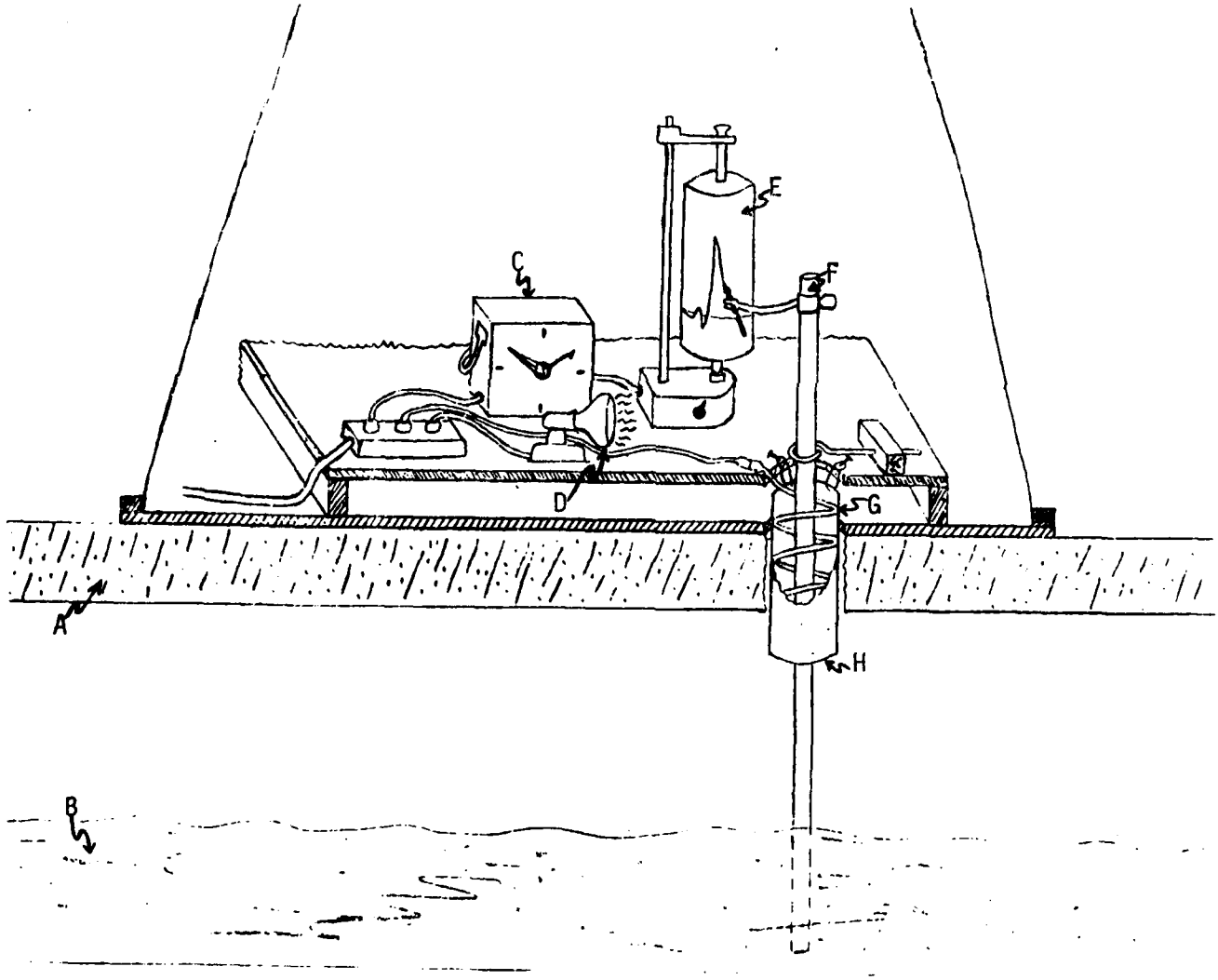
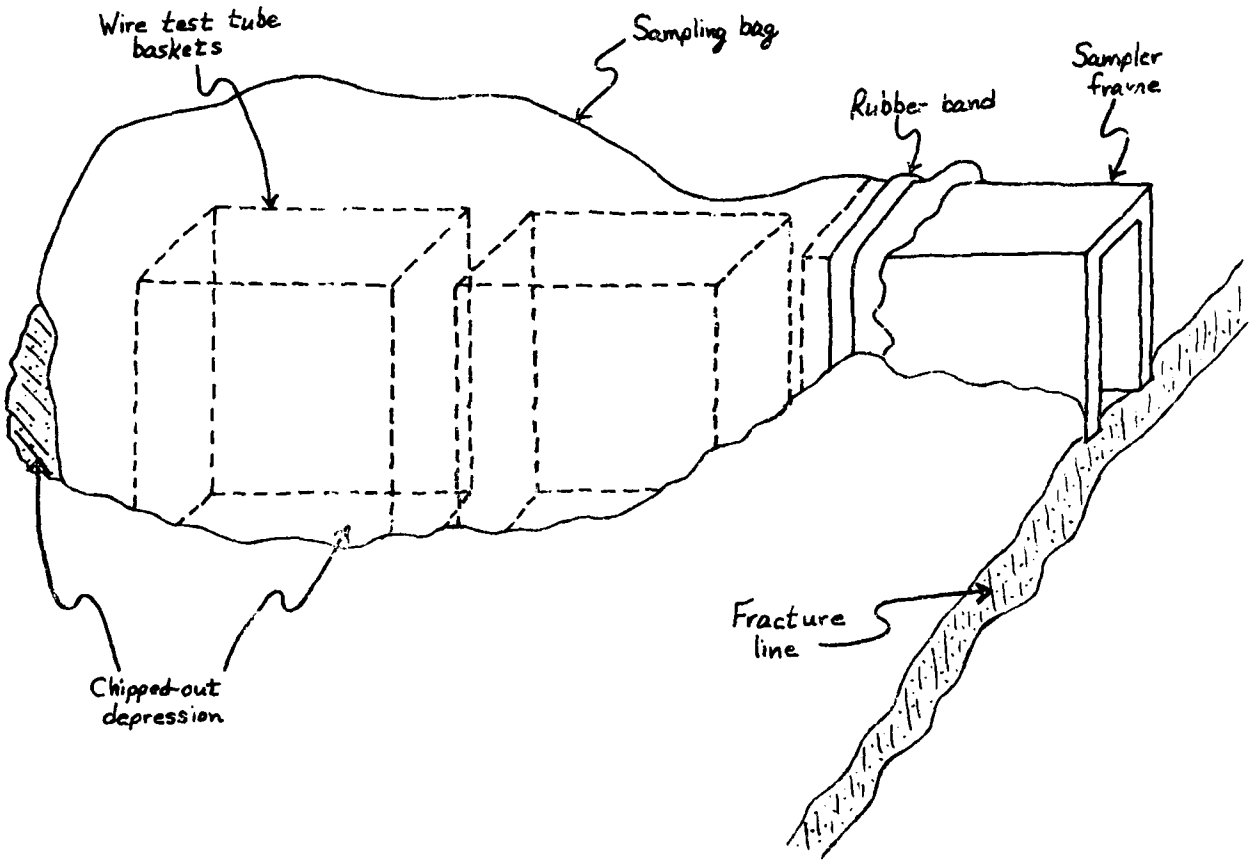


Figure 8 - A) ice sheet; B) bottom; C) timer; D) heat lamp; E) kymograph; F) iron pipe with attached writing instrument; G) heating cable; H) protective sleeve

SURFACE SAMPLING APPARATUS
Figure 9



ANALYSIS OF DATA

Ice movement was monitored during vessel passages from January 26 to March 27, 1979 as part of the benthic displacement study. During this time vertical ice movement values were found to range from 2.8 cm to 72.5 cm, depending on vessel length, speed and other conditions (Table 1). Crack samples were also taken during this time. Out of the twenty samples taken there were only five which contained benthic organisms and these correspond with the five largest vertical ice displacement values that were recorded. These five samples resulted from 3 vessel passages, since at times there were 2 different size samplers in place for each vessel passage. There appears to be a correlation between benthic loss to surface ice and vertical ice displacement, however this is only at extreme and maximum values. With reference to winter navigation it appears that under "normal" conditions and at regulated vessel speeds (i.e. the Coast Guard vessel speed limits) there would be little damage to existing benthic populations as a result of displacement to surface ice due to winter shipping.

In general it was found that for vessels of the same length and traveling at the same rate of speed, an upbound vessel will cause much more vertical ice displacement than a downbound one will. Two of the three successful events producing crack samples that contained benthic organisms were from upbound vessels and were also maximum ice displacement values (all greater than 64 cm vertical displacement). The other one was from a downbound vessel with a vertical displacement value of

Analysis of Data (Continued)

71.2 cm. There was only one vessel with a vertical displacement value greater than 64 cm for which there were no benthic organisms present in its corresponding sample (Arthur M. Anderson, upbound, March 27). All samples associated with vertical ice displacement values less than 64 cm contained no benthic organisms (Table 2).

Bottom sample data served as an indicator of relative abundance of benthic organisms. It was used as a guideline in evaluating the crack sample data (Appendix B and C). By far the most abundant of the organisms found in the bottom samples were snails (Gastropoda), which made up 45% of all samples. The majority of the rest of the sample was composed of Diptera (17.4%), Annelida (17.3%), and Pelecypoda (12.4%). All other benthic organisms combined made up the remaining 8% (Table 3).

Crack sample data was taken from February 16 through March 27. There were 20 attempted samplings during this period, of which 10 of them produced crack samples. Of these there were only five that contained benthic organisms. The most abundantly occurring organisms were Dipterans which accounted for 75% of the organisms displaced, Annelida made up 15%, and Ostracods 10%. The most organisms collected in one sampler was 7 (5 Dipterans and 2 Annelids) on March 27 from the Phillip R. Clark's passage.

From February 16 through March 7 there was very little traffic due to extremely cold conditions and the resulting heavy ice build up (Figure 10). Following this there was a slight thaw for the next 10 days. Then

Analysis of Data (Continued)

on the evening of March 18 the passages of the Cason J. Callaway and Roger Blough completely shattered the ice fields at Riverview and Doran's and had only a slight impact at Adam's. The field was broken into many large ice floes ranging in size from a few feet across to as much as 25 feet across in some cases. There was a great deal of sediment deposition on surface ice and in some places large clumps of aquatic vegetation were deposited at the edges of fractures as they shifted. These clumps were taken to the lab and carefully analyzed, however they were found to be almost completely devoid of benthic organisms. Though the break up was quite dynamic in the physical sense, there was very little apparent affect on the benthic communities involved, with regard to displacement to surface ice.

From the bottom sample data the average benthic density was found to be 9,593 organisms per square meter. Of the 20 attempted samplings there were a total of 21 organisms collected, or about one organism per vessel passage. Further calculations show that for a one meter length of crack there would be approximately 10 organisms displaced per vessel passage, or about 0.1% of the existing benthic population.

VERTICAL ICE DISPLACEMENT DATA
Table 1

Vessel Description	Direction	(cm) Ice Depth	(cm) Vertical Ice Displacement	(sec.) Recovery Time
0-400 Ft. (0-118.5 m)				
5-10 mph (8-16 kph)				
C. G. C. Mackinaw	Upbound	33	25	36
C. G. C. Mackinaw	Upbound	35	11.2	90
Over 10 mph (16 kph)				
C.G.C. Katamai Bay	Upbound	25	4.2	24
400-700 Ft. (118.5-207.4 m)				
0-5 mph (0-8 kph)				
Hudson Transport	Downbound	33	2.8	30
5-10 mph (8-16 kph)				
Enders M. Vorhees	Upbound	25	14.7	42
Doan Transport	Upbound	33	19	54
Leon Fraser	Downbound	33	14.5	36
John G. Munson	Upbound	35	63	144
Imperial St. Clair	Upbound	46	48	156
Imperial St. Clair	Downbound	46	15.3	18
Imperial St. Clair	Upbound	38	7.5	78
Arthur M. Anderson	Downbound	42	72.5	48
Arthur M. Anderson	Upbound	44	19.7	42
John G. Munson	Upbound	44	26.3	54
Over 10 mph (16 kph)				
Imperial St. Clair	Upbound	40	23.5	72
700-1000 Ft. (207.4-296.3 m)				
0-5 mph (0-118.2 kph)				
Edwin H. Gott	Upbound	35	20.8	57
5-10 mph (8-16 kph)				
Presque Isle	Downbound	33	12.8	48
Philip R. Clark	Upbound	35	24	108
Calvin J. Callaway	Upbound	35	60	174
Robert Bleum	Downbound	40	12.2	72
Calvin J. Callaway	Downbound	48		84
Over 10 mph (16 kph)				
Calvin J. Callaway	Downbound	33	2.2	24
Philip R. Clark	Downbound	42	7.2	30
Philip R. Clark	Upbound	41	47.6	42

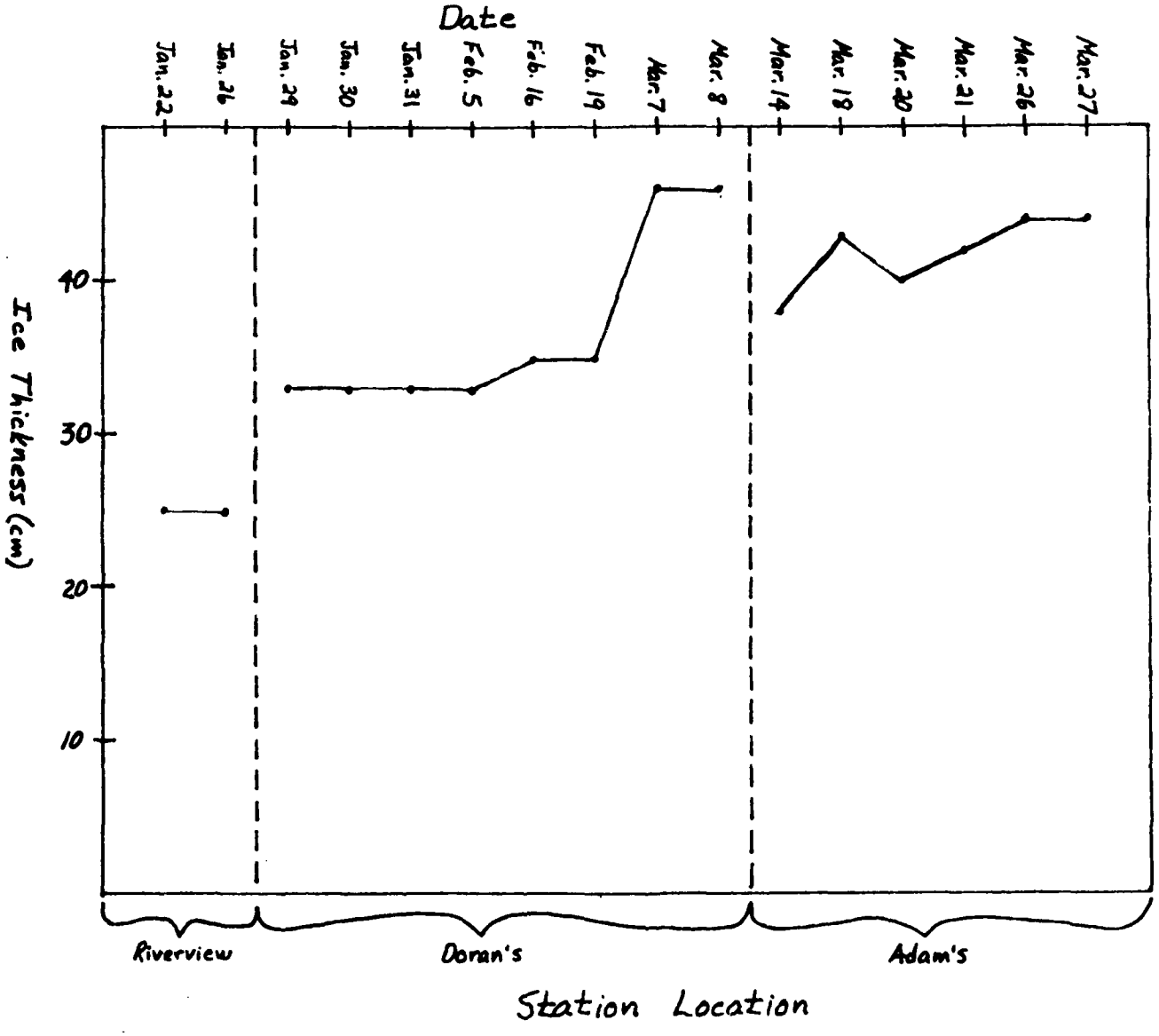
BENTHIC PERCENT COMPOSITION OF BOTTOM SAMPLES
Table 2

DATE	LOCATION	VESSEL	DIRECTION	(cm) SAMPLER SIZE	BENTHIC ORGANISMS DISPLACED
2-16	Doran's	Phillip R. Clark	Upbound	16	Diptera Chironomidae Orthocladiinae (2) Tanypodinae (3) Heleidae (1)
3-7	Doran's	Imperial St. Clair	Upbound	16	None
3-7	Doran's	Imperial St. Clair	Upbound	8	None
3-8	Doran's	Imperial St. Clair	Downbound	16	None
3-8	Doran's	Imperial St. Clair	Downbound	8	None
3-14	Adam's	Imperial St. Clair	Upbound	16	None
3-18	Doran's	Roger Blough	Upbound	10	Diptera Chironomidae Chironominae (1) Orthocladiinae (2) Tanypodinae (1)
3-18	Adam's	Roger Blough	Upbound	16	None
3-18	Adam's	Roger Blough	Upbound	8	Diptera Chironomidae Chironeminae (1) Annelida (1)
3-20	Adam's	Imperial St. Clair	Upbound	16	None
3-20	Adam's	Imperial St. Clair	Upbound	8	None
3-21	Adam's	Arthur M. Anderson	Downbound	16	None
3-21	Adam's	Arthur M. Anderson	Downbound	8	None
3-21	Adam's	Phillip R. Clark	Downbound	16	Ostracoda (2) Annelida (2) Diptera Chironomidae Orthocladiinae (3) Tanypodinae (2)
3-21	Adam's	Phillip R. Clark	Downbound	8	
3-26	Adam's	Roger Blough	Downbound	10	None
3-26	Adam's	Cason J. Callaway	Downbound	10	None
[illegible]	Adam's	Phillip R. Clark	Upbound	10	None
[illegible]	Adam's	Arthur M. Anderson	Upbound	8	None
[illegible]	Adam's	John G. Munson	Upbound	8	None

DISTRIBUTION IN PERCENT
OF BENTHOS AT SAMPLE STATIONS
TABLE 3

Order	Riverview	Doran's	Adam's	Mean For All Stations
GASTROPODA	49.2	57.8	28.2	45.1
DIPTERA	8.1	17.7	26.5	17.4
ANNELIDA	22.3	10.9	18.8	17.3
PELECYPODA	10.9	7.7	18.7	12.4
AMPHIPODA	2.4	2.4	0.3	1.7
HYDRACARINA	2.7	1.8	0.3	1.6
TRICHOPTERA	1.9	0.9	1.6	1.5
EPHEMEROPTERA	1.9	0.3	2.1	1.4
NEMATODA	0.2	0.3	1.9	0.9
ISOPODA	0.3	0.1	1.6	0.7
MEGALOPTERA	0.0	0.1	0.0	0.03

ICE THICKNESS DURING SAMPLING PERIOD
Figure 10



CONCLUSIONS AND RECOMMENDATIONS

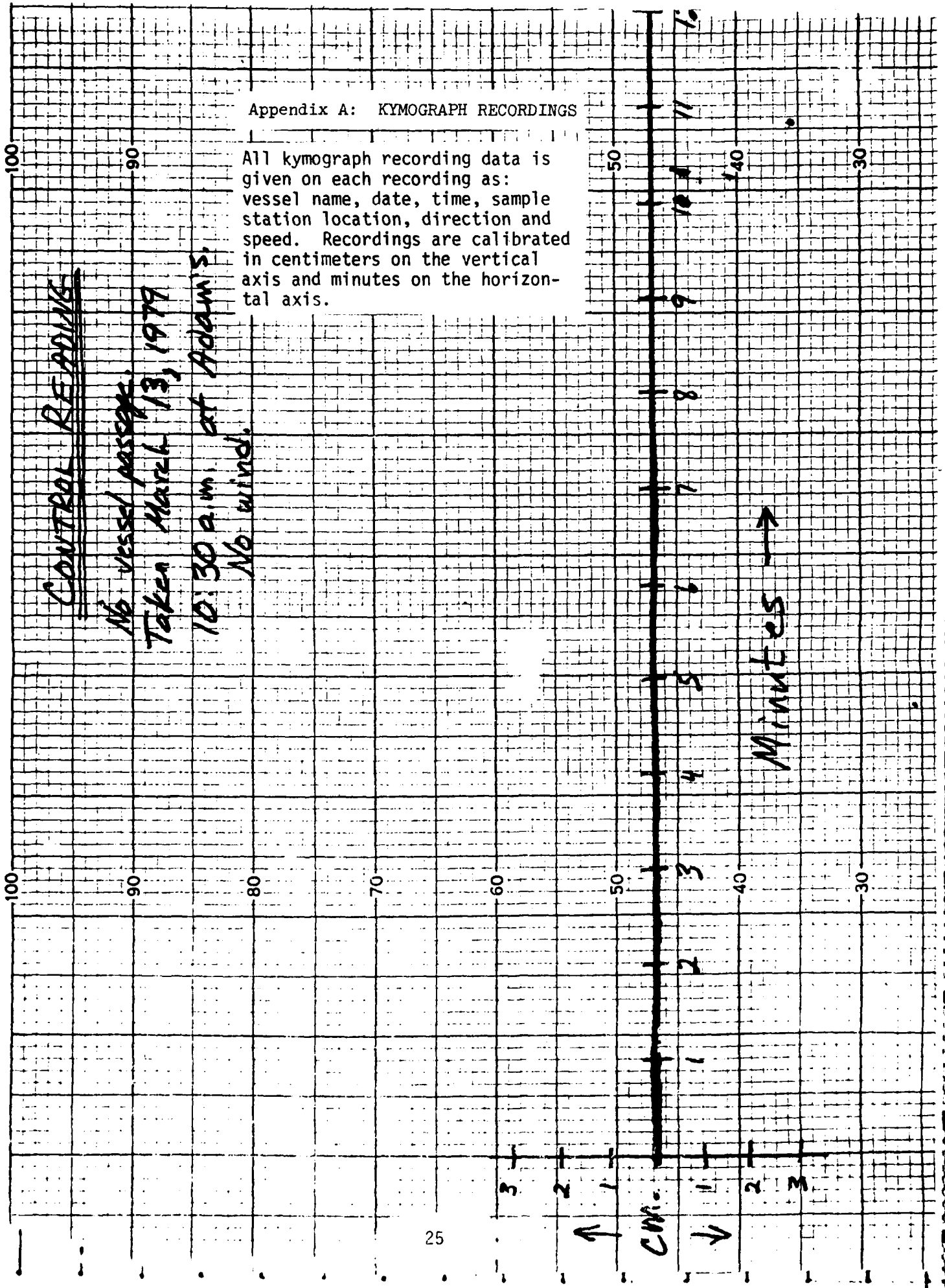
The results of the investigation conducted during the winter of 1978-79 on the effects of pressure wave displacement of benthic organisms to the ice surface and subsequently lost to the environment proved to be insignificant. Observations during past winters (1976-77 and 1977-78) would indicate that the winter of 1978-79 was not characteristic as it relates to the frequency of relief cracks and the subsequent ice surface contamination by sediments and benthos.

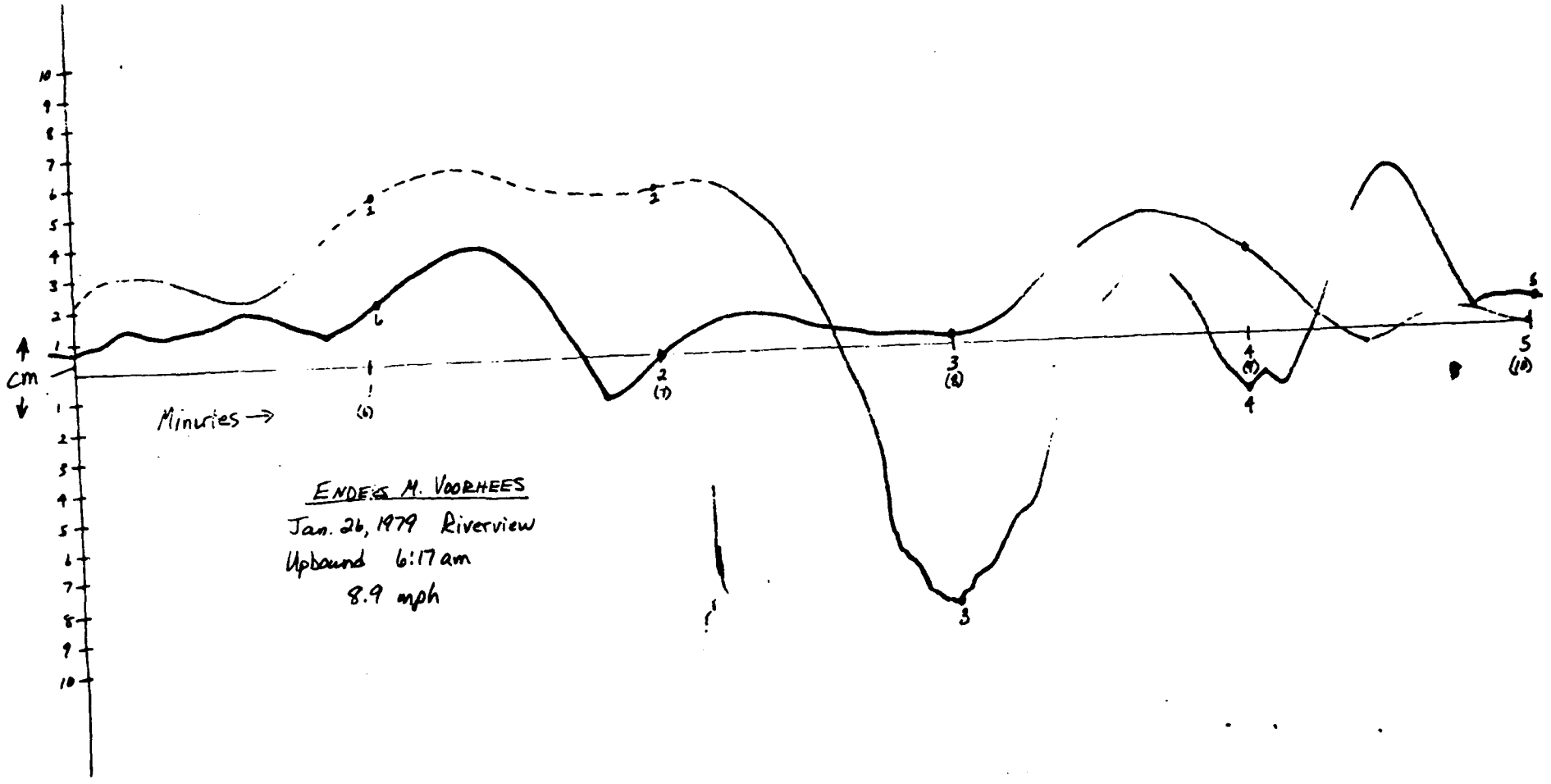
The minimal affect experienced during 1978-79 can be attributed to the decrease in shipping activity (number of vessels per week), the mode of ice breaking (Katamai Bay vs. the Mackinaw) and the rate and type of ice formation due to the winter. If the frequency of activity by upbound and downbound vessels had been maintained at 4+ passages per week and if the Mackinaw had been used for ice breaking, the previously observed shore ice - sheet ice junctures would have maintained the open fractures through which the benthic dislocation affect had been observed in the past. The degree in frequency coupled with the extremely cold periods of extended freezing allowed interstitial ice to become strong enough that only when vessels reached critical speeds did new fractures form. Early winter fractures occurred very close to shore and produced only water and some fine sands. These reaches of the littoral zone are traditionally low or devoid of benthic representatives. It is not until the shore ice has moved out to a depth of 1 to 1.5 meters that aquatic invertebrates and vertebrates appear on the ice surface. The investigation carried out by Lake Superior State College would indicate that ice surface loss under present conditions of

operation (1978-79) does not merit further study and that the losses to the system are insignificant in comparison to the annual mortality associated with the area studied. This recommendation does not exclude the possibility that subsurface dislocation and disruption of the benthic ecology does exist.

Appendix A: KYMOGRAPH RECORDINGS

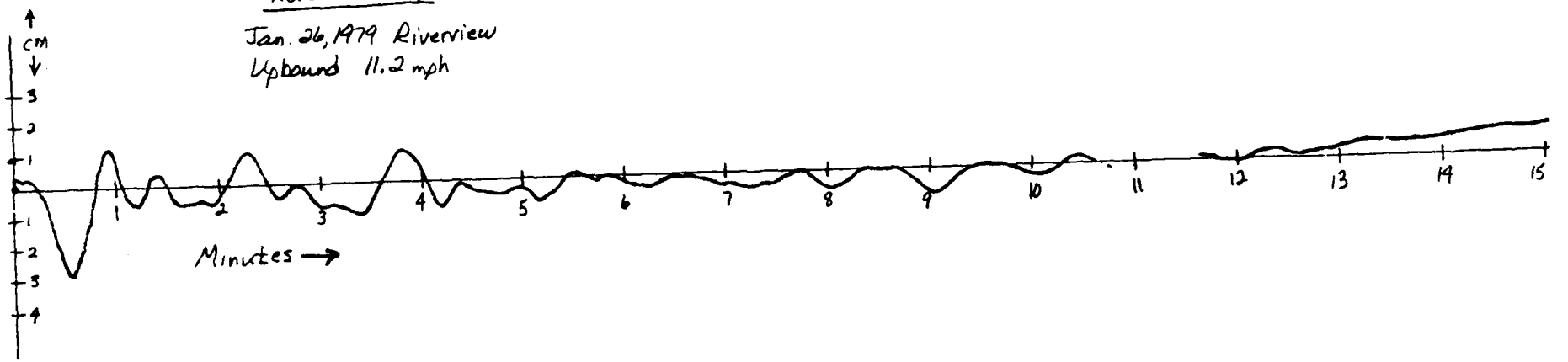
All kymograph recording data is given on each recording as: vessel name, date, time, sample station location, direction and speed. Recordings are calibrated in centimeters on the vertical axis and minutes on the horizontal axis.

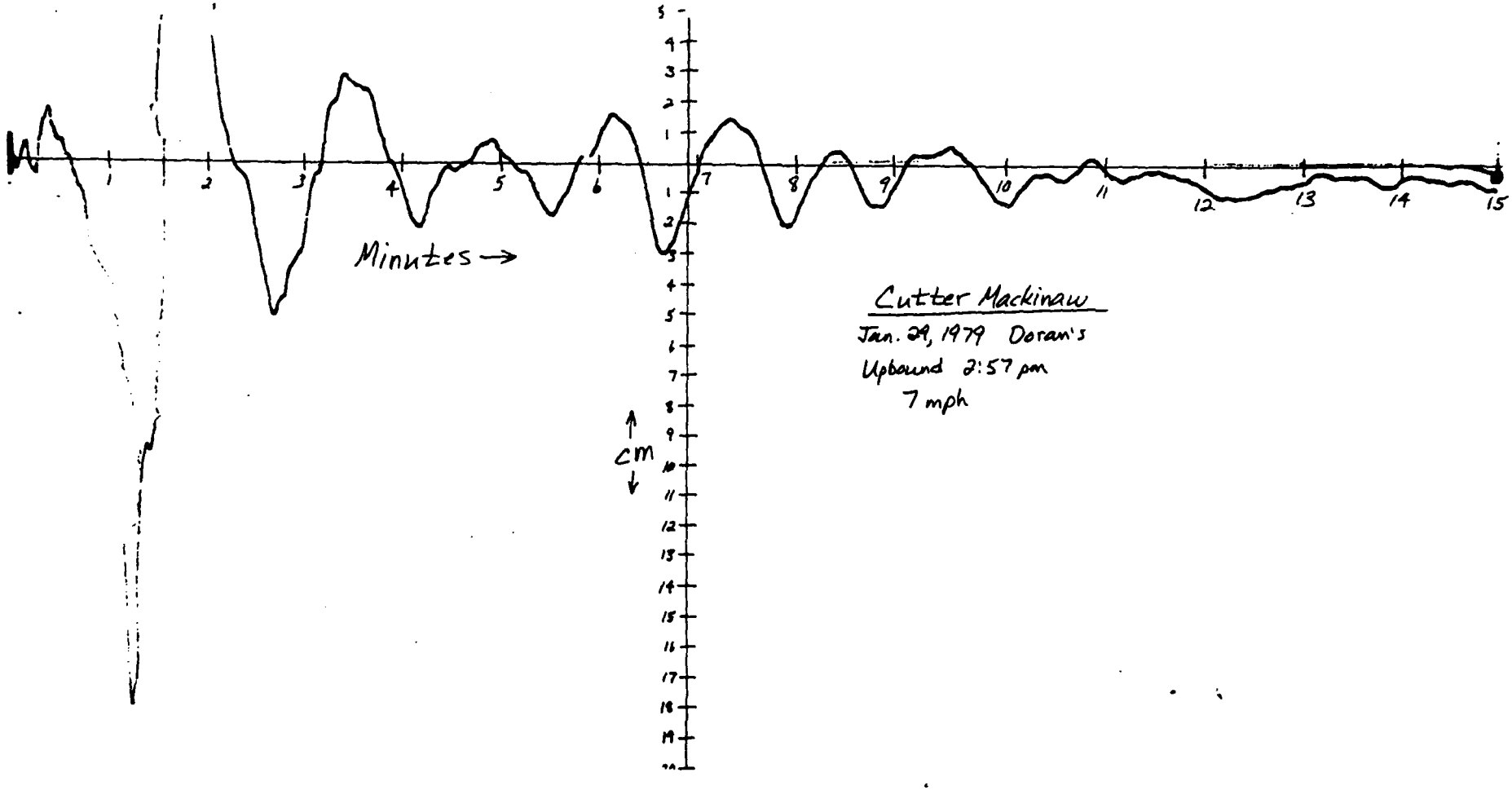


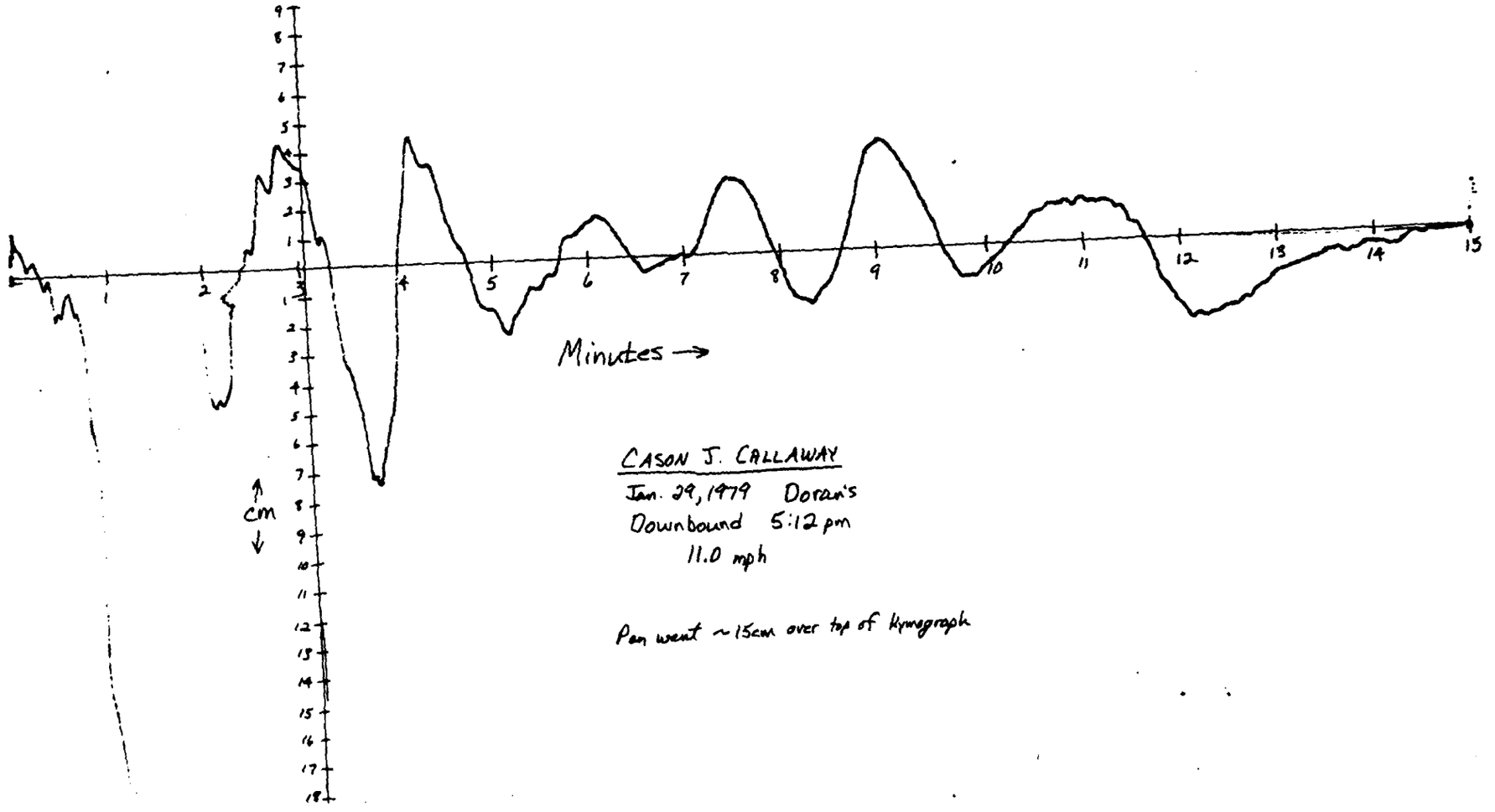

cm
Minutes →
ENDERS M. VOORHEES
Jan. 26, 1979 Riverview
Upbound 6:17 am
8.9 mph

Katamai Bay

Jan. 26, 1979 Riverview
Upbound 11.2 mph

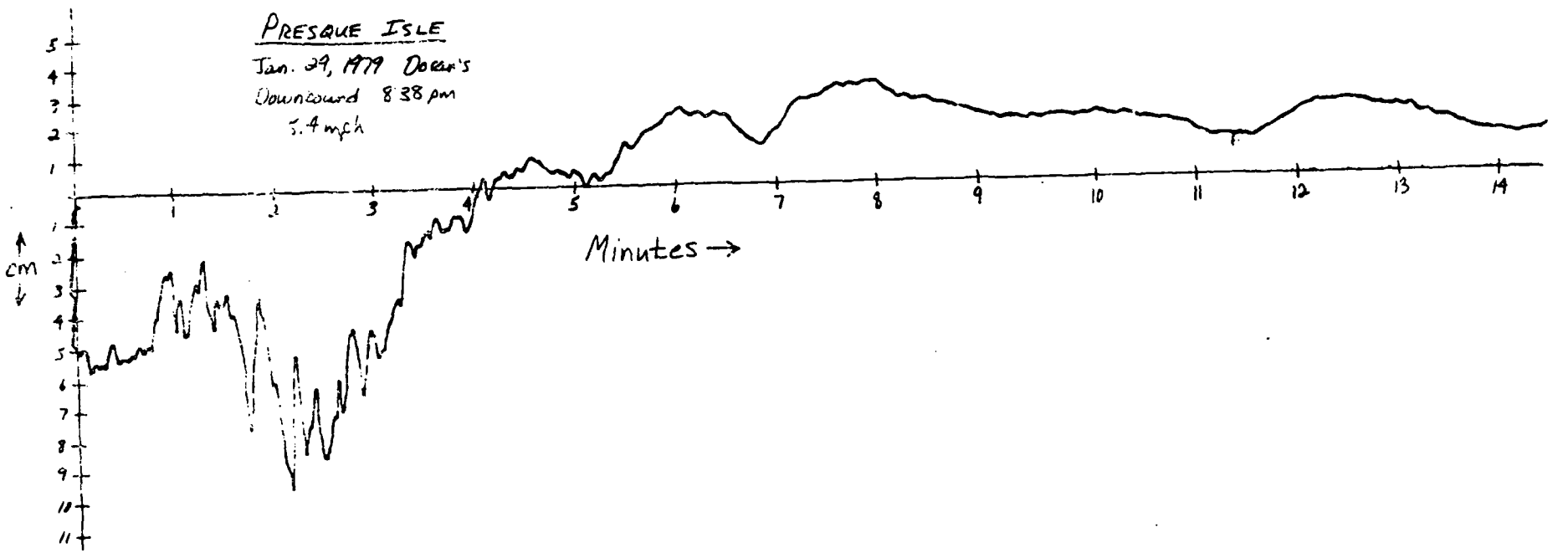


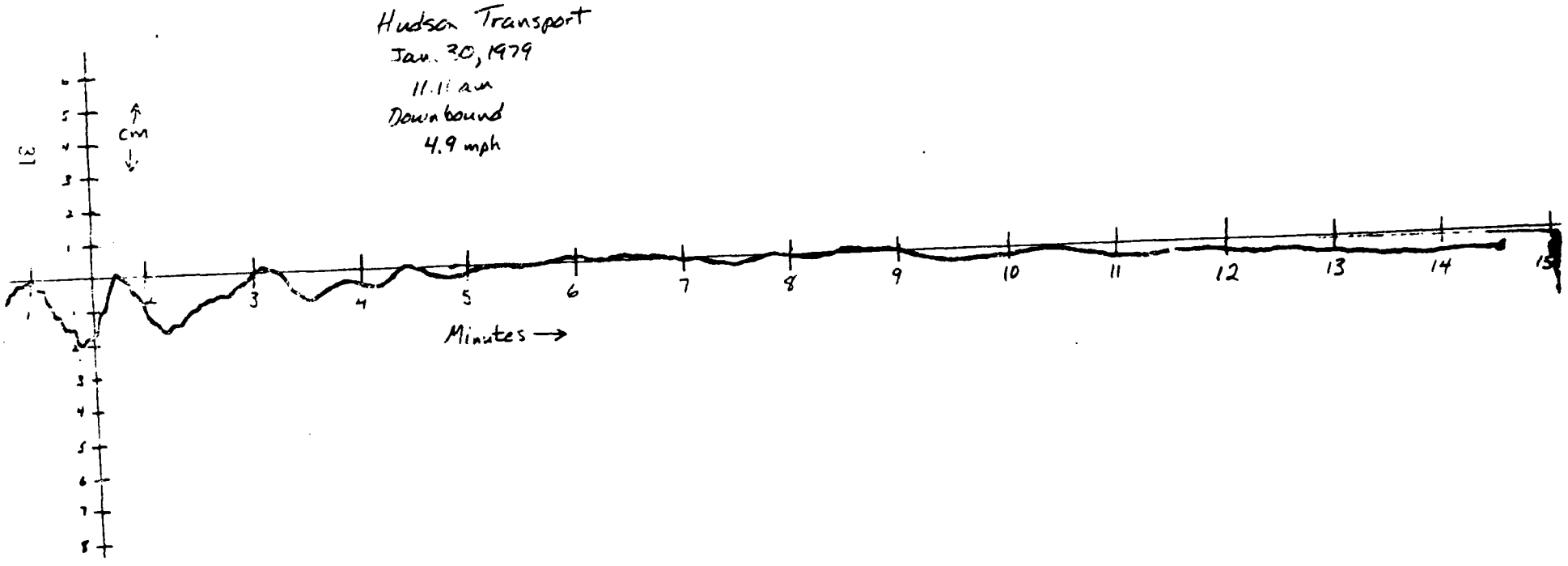

Minutes →
cm
Cutter Mackinaw
Jan. 29, 1979 Doran's
Upbound 2:57 pm
7 mph

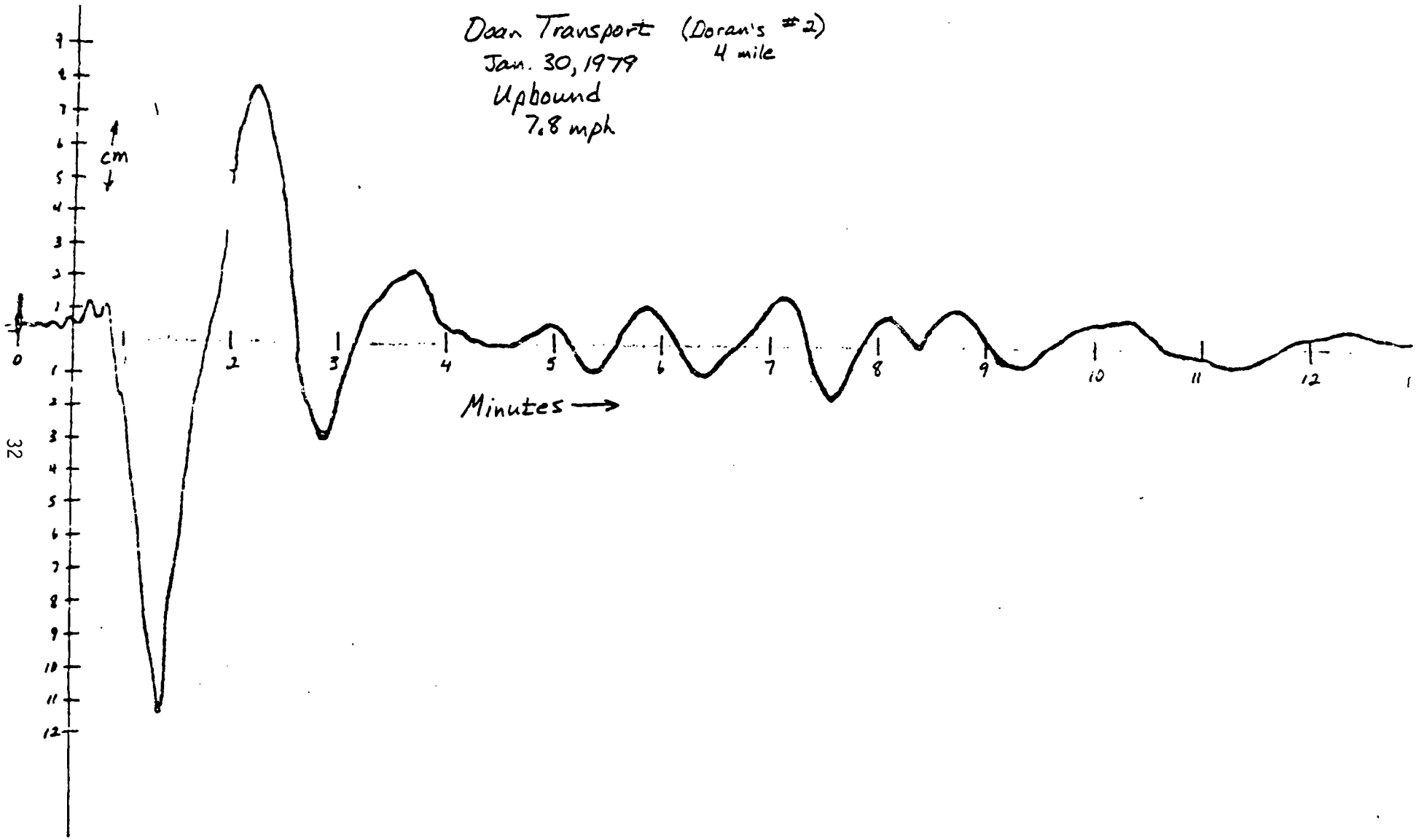


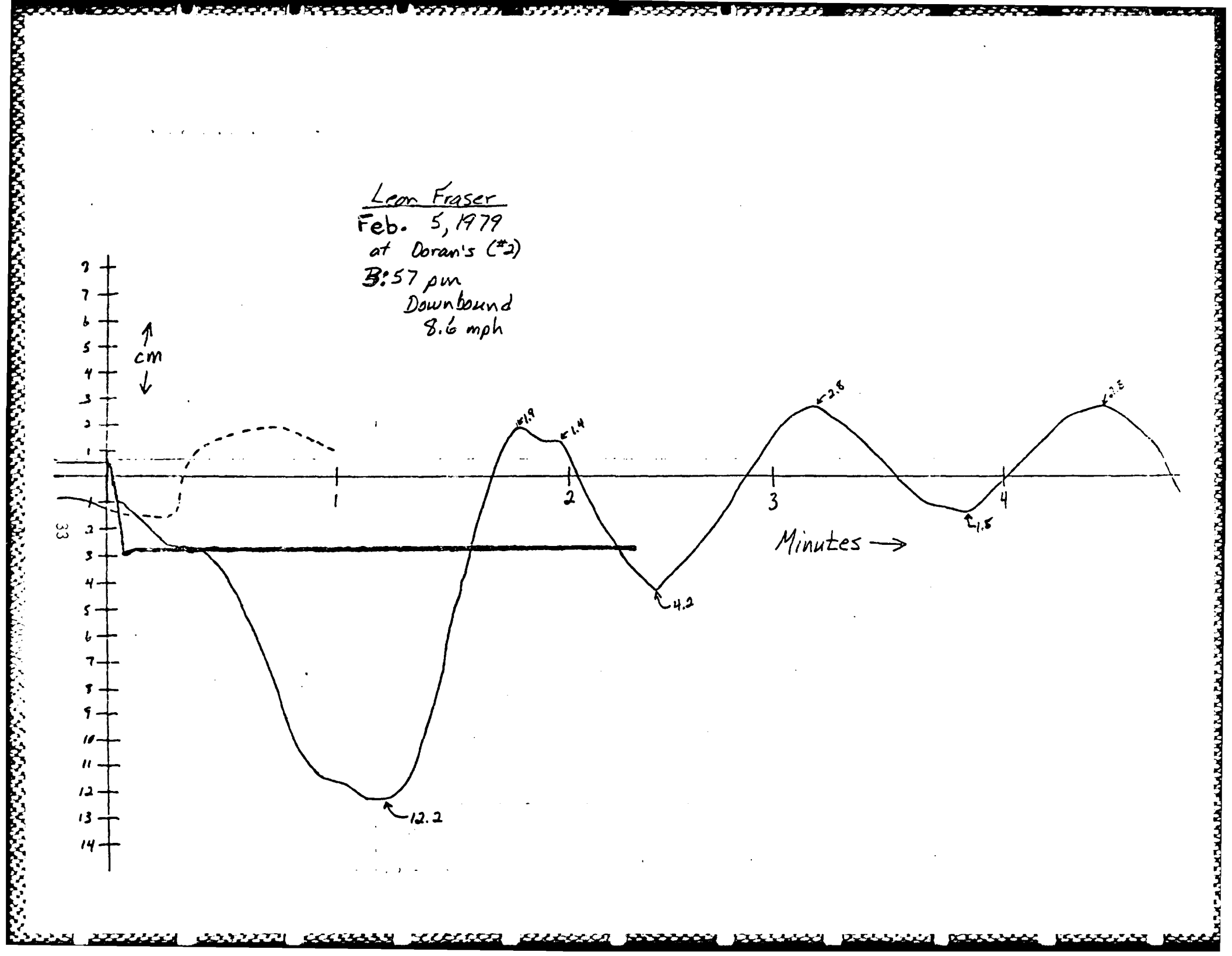
CASON J. CALLAWAY
Jan. 29, 1979 Doran's
Downbound 5:12 pm
11.0 mph

Pen went ~15cm over top of hydrograph


PRESQUE ISLE
Jan. 29, 1979 Doker's
Downcoward 8:38 pm
5.4 m/h
Minutes →
cm


Hudson Transport
Jan. 30, 1979
11:11 am
Downbound
4.9 mph
cm
Minutes →


Doan Transport (Doran's #2)
Jan. 30, 1979
4 mile
Upbound
7.8 mph
cm
Minutes →


Leon Fraser
Feb. 5, 1979
at Doran's (#2)
8:57 pm
Downbound
8.6 mph
cm
Minutes →
1
2
3
4
12.2
4.2
1.5
33

C. G. Cutter Mackinac

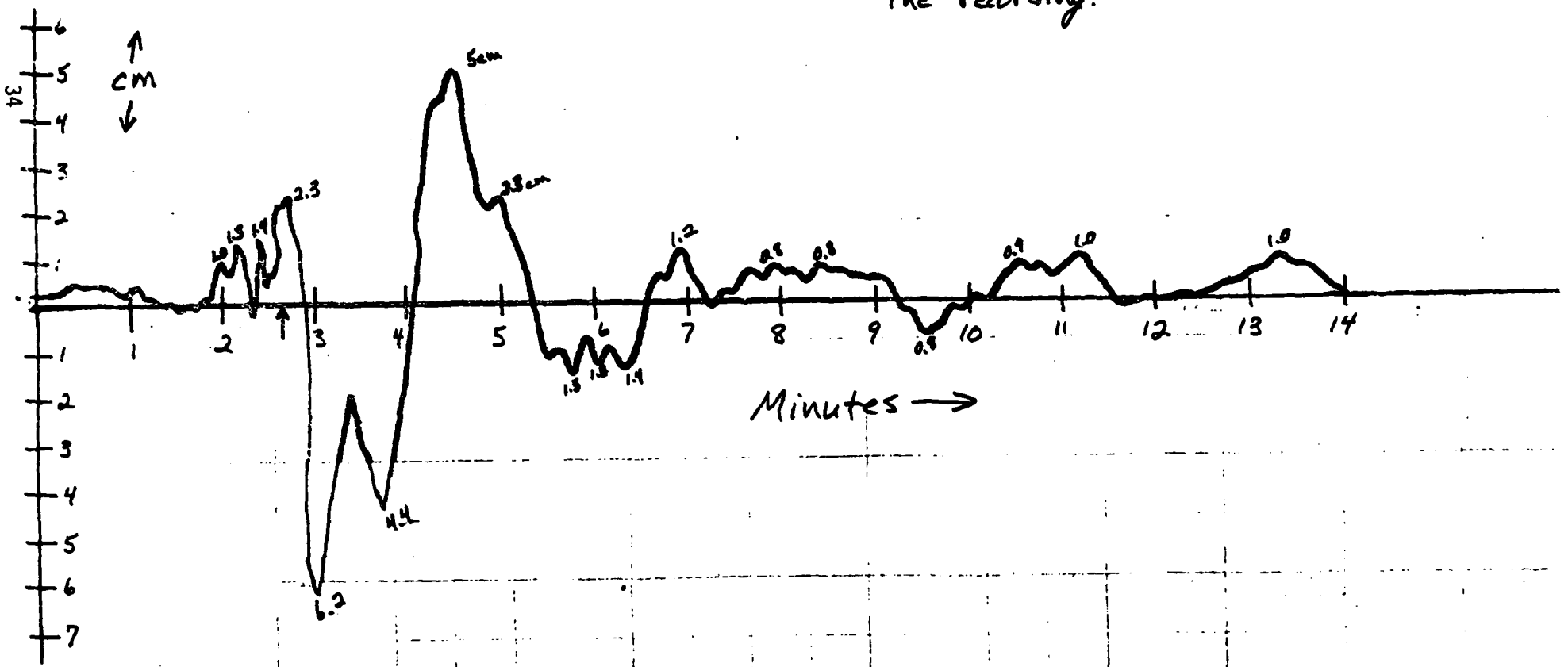
Feb. 16, 1979

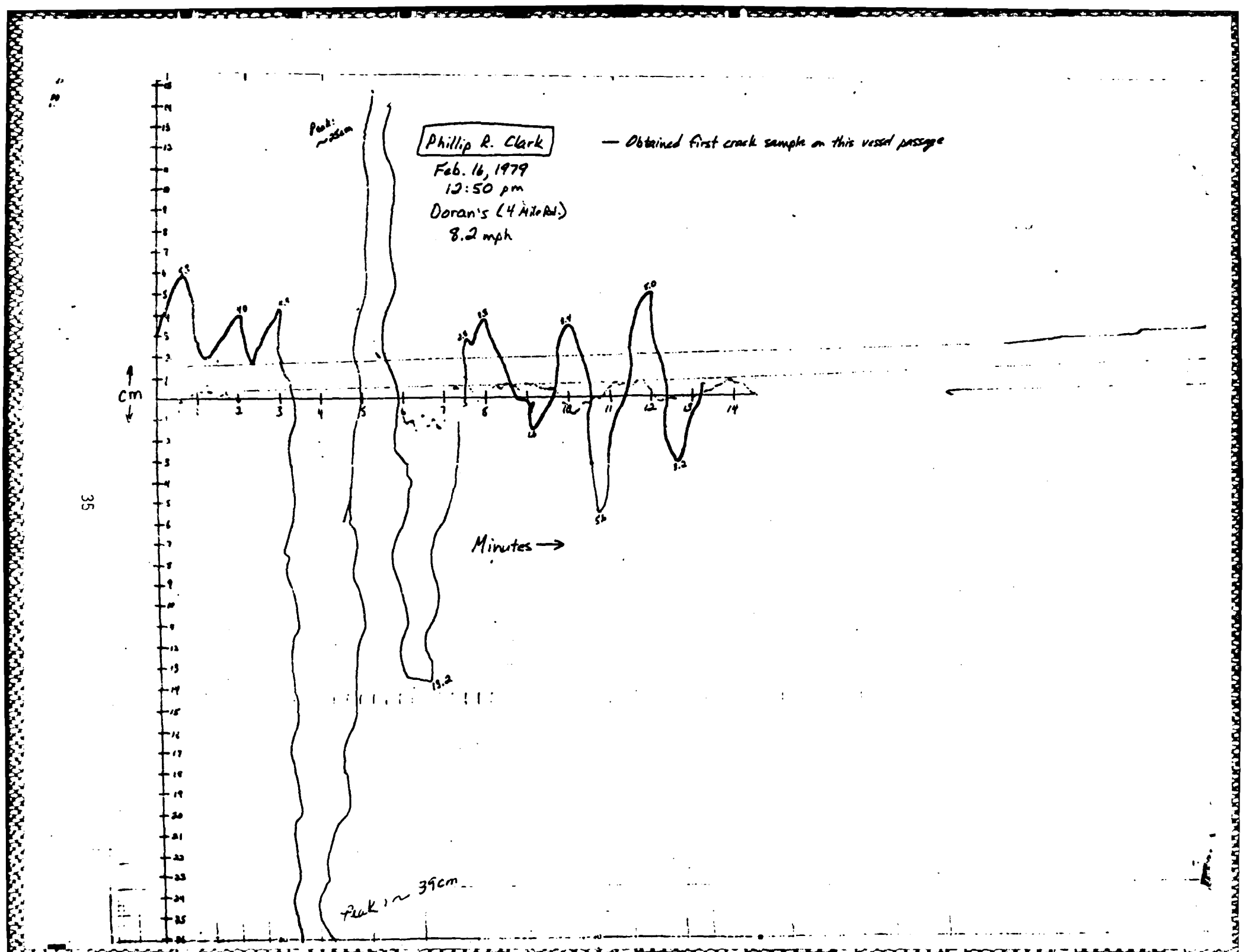
10:30 a.m.

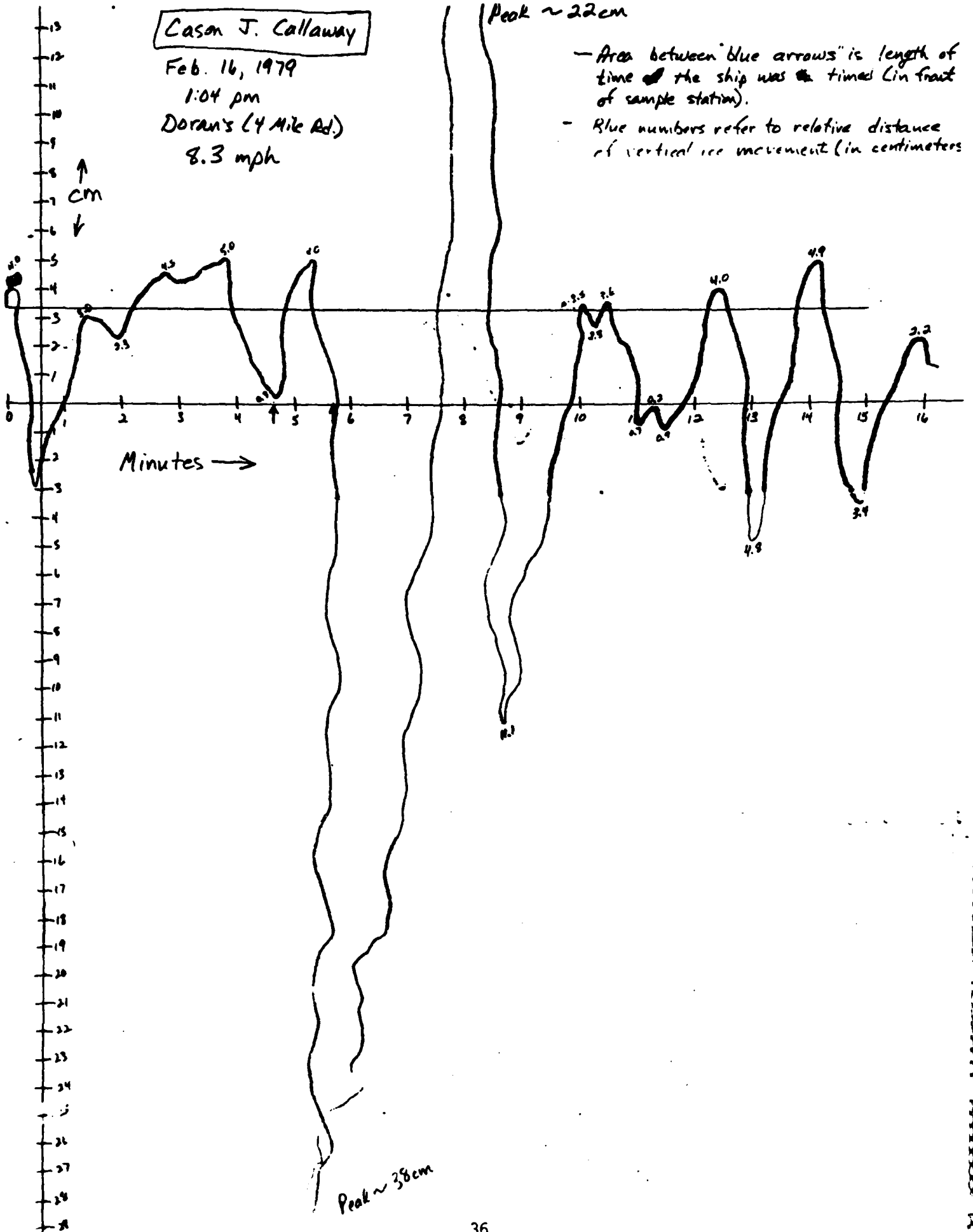
Doran's (4 mile road)

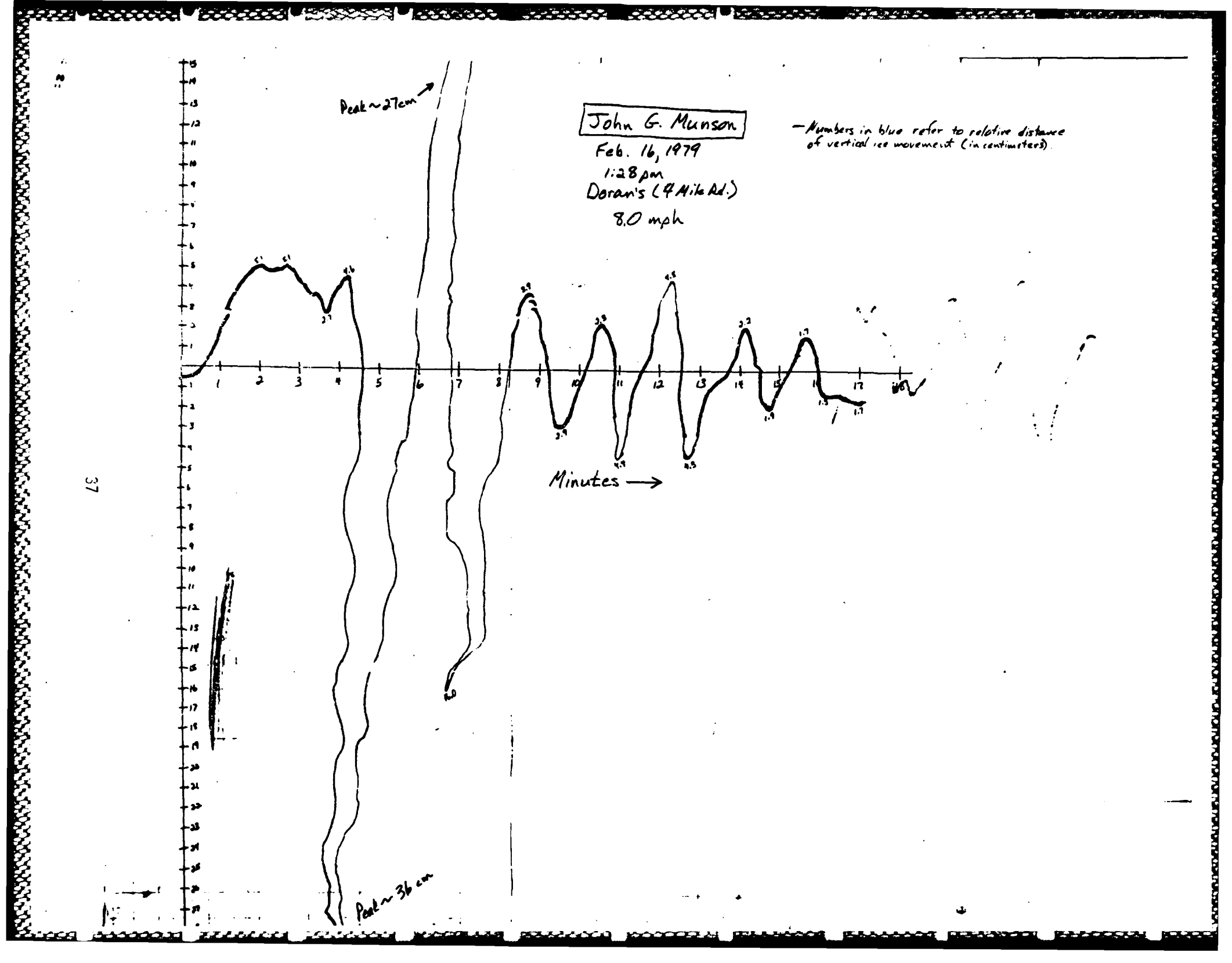
7.2 mph

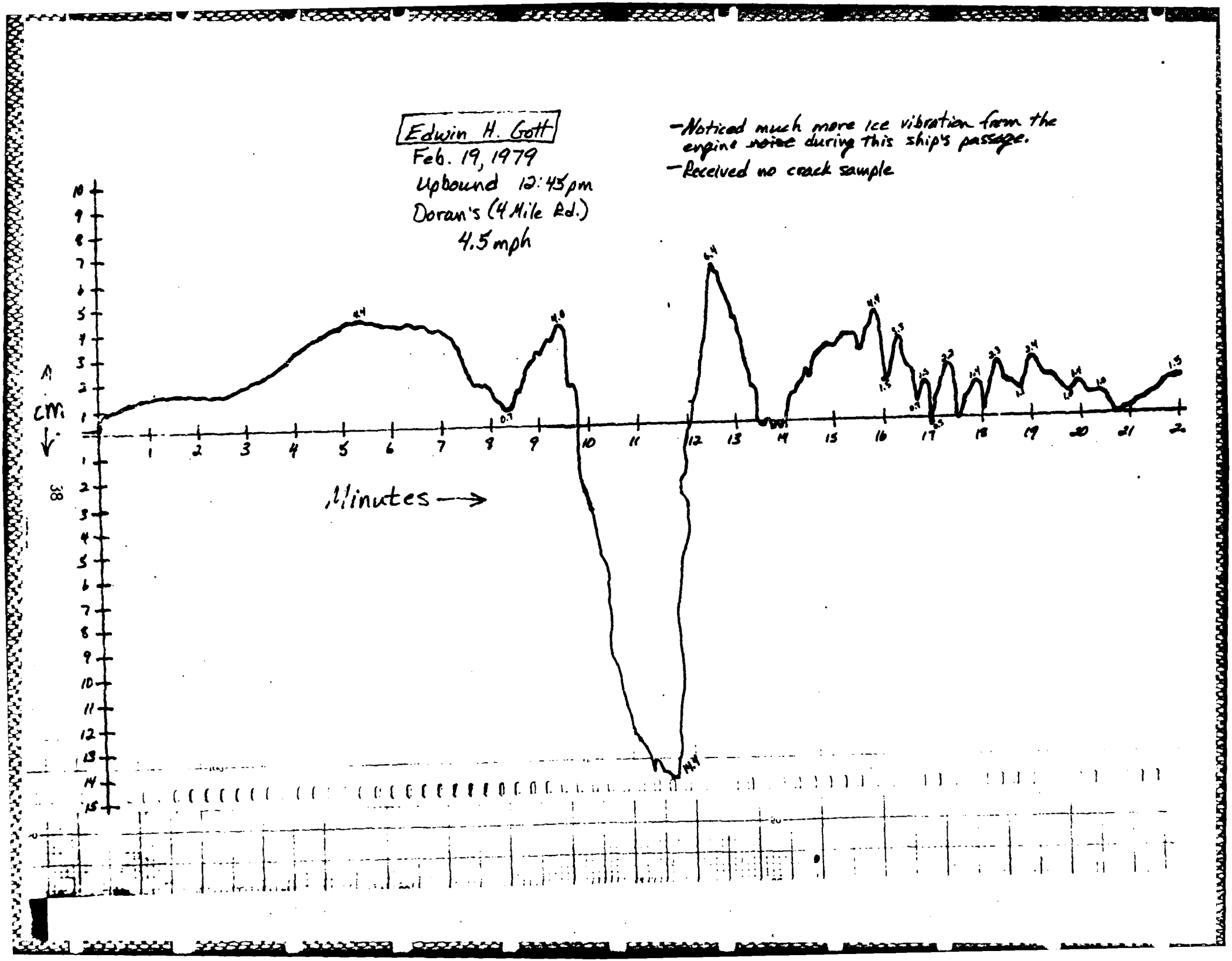
- Mackinac was breaking channel open for 3 upbounders (i.e. Clark, Calloway, + Munson) Last ship thru was near noon on Wednesday, thus approx. 2 days of ice build-up.
- Blue arrow indicates where Mackinac began backing up - right in front of the sample location. She continued backing up for the duration of the recording.

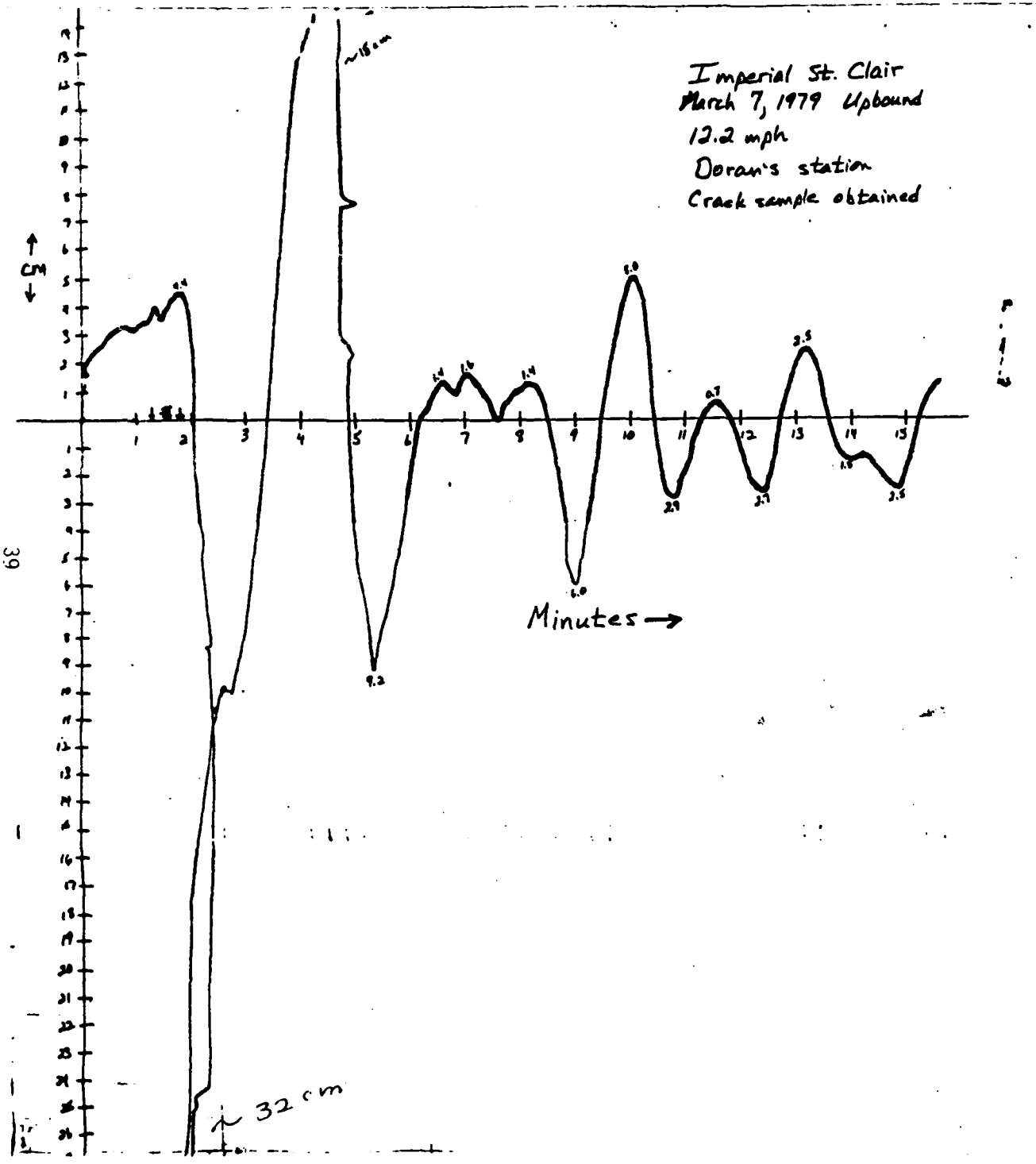


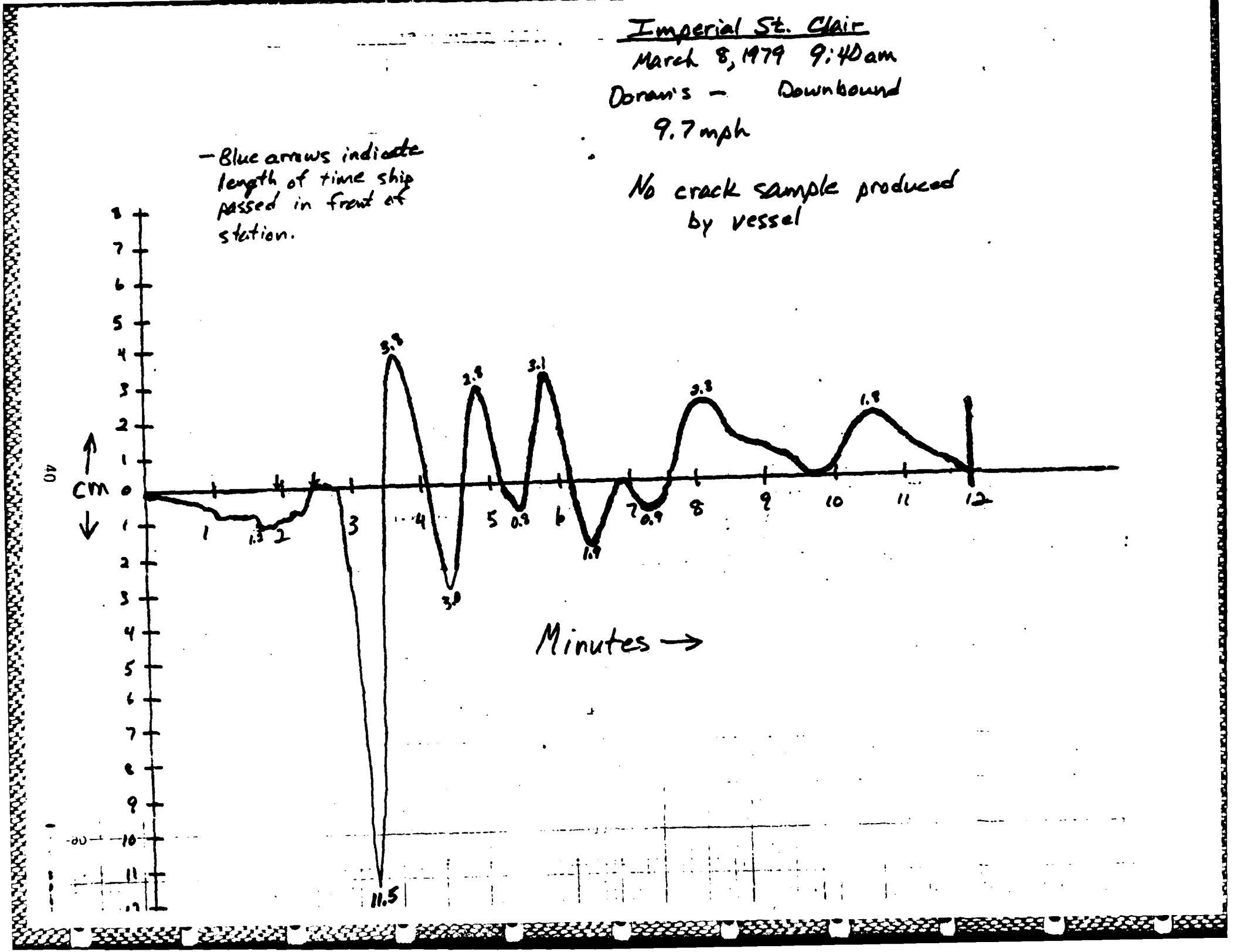

Phillip R. Clark
— Obtained first crack sample on this vessel passage
Feb. 16, 1979
12:50 pm
Doran's (4 Mile Rd.)
8.2 mph
Peak ~ 35cm
cm
Minutes →
Peak ~ 39cm


Cason J. Callaway
Feb. 16, 1979
1:04 pm
Doran's (4 Mile Rd.)
8.3 mph
Peak ~ 22cm
— Area between "blue arrows" is length of time the ship was timed (in front of sample station).
- Blue numbers refer to relative distance of vertical ice movement (in centimeters
cm
Minutes →
Peak ~ 38cm


John G. Munson
Feb. 16, 1979
1:28 pm
Doran's (9 Mile Rd.)
8.0 mph
—Numbers in blue refer to relative distance of vertical ice movement (in centimeters).
Peak ~ 27cm
Peak ~ 36 cm
Minutes →


Edwin H. Gott
Feb. 19, 1979
Upbound 12:45pm
Doran's (4 Mile Rd.)
4.5 mph
-Noticed much more ice vibration from the engine noise during this ship's passage.
-Received no crack sample
cm.
Minutes →
38


Imperial St. Clair
March 7, 1979 Upbound
12.2 mph
Doran's station
Crack sample obtained
- 2 blue arrows indicate when vessel was timed directly in front of station, 30.6 sec. .
CM
Minutes →
~16 cm
32 cm


Imperial St. Clair
March 8, 1979 9:40am
Doran's – Downbound
9.7 mph
– Blue arrows indicate length of time ship passed in front of station.
No crack sample produced by vessel
cm
Minutes →
3.9
2.9
3.1
3.8
1.8
3.0
1.9
11.5
0.9
0.9
1
1.5
2
3
4
5
6
7
8
9
10
11
12

IMPERIAL ST CLAIR

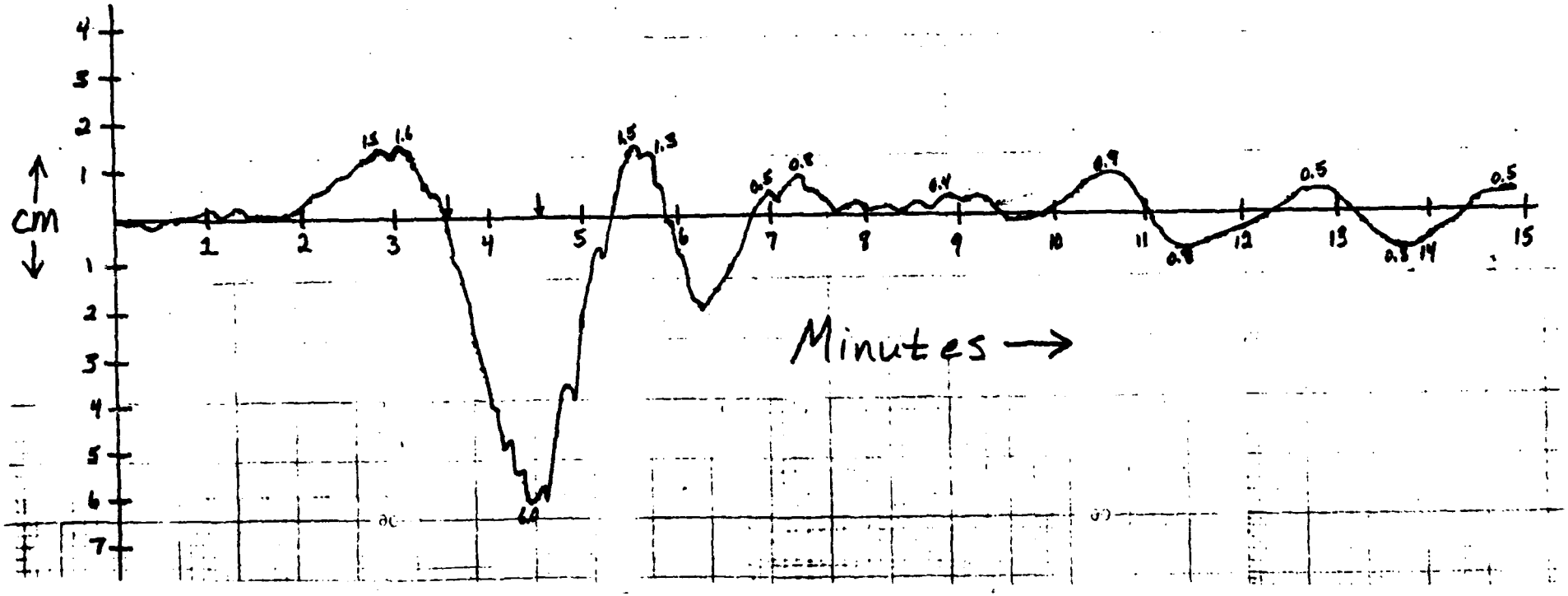
March 14, Adam's - 11:02 a.m.

Upbound at 6.3 mph

Ice thickness 38 cm

Crack sample obtained - 350 ml

- Blue arrows indicate length of time of vessel passage in front of station.



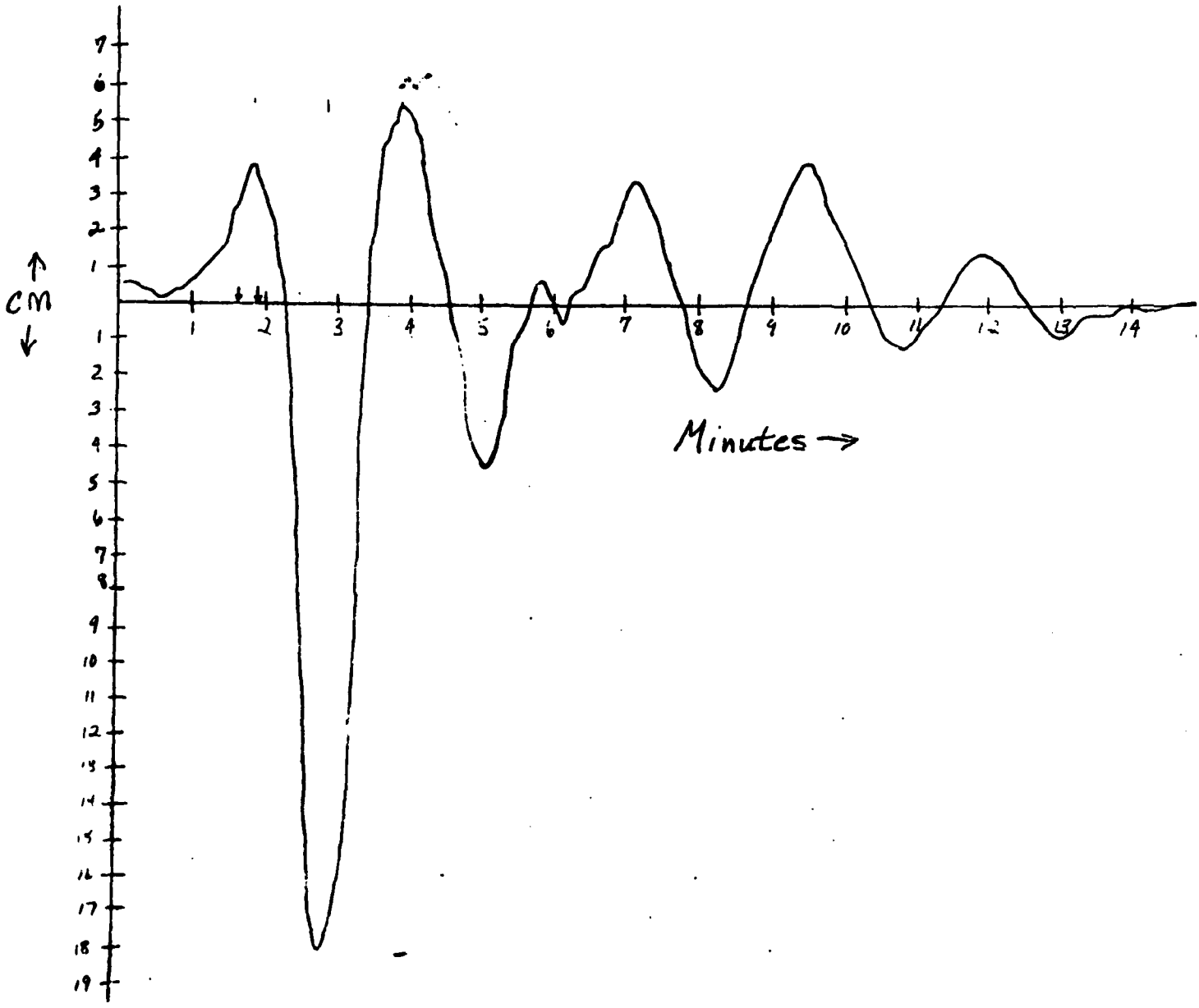
IMPERIAL ST. CLAIR

March 20, 1979 Upbound 11:30 am

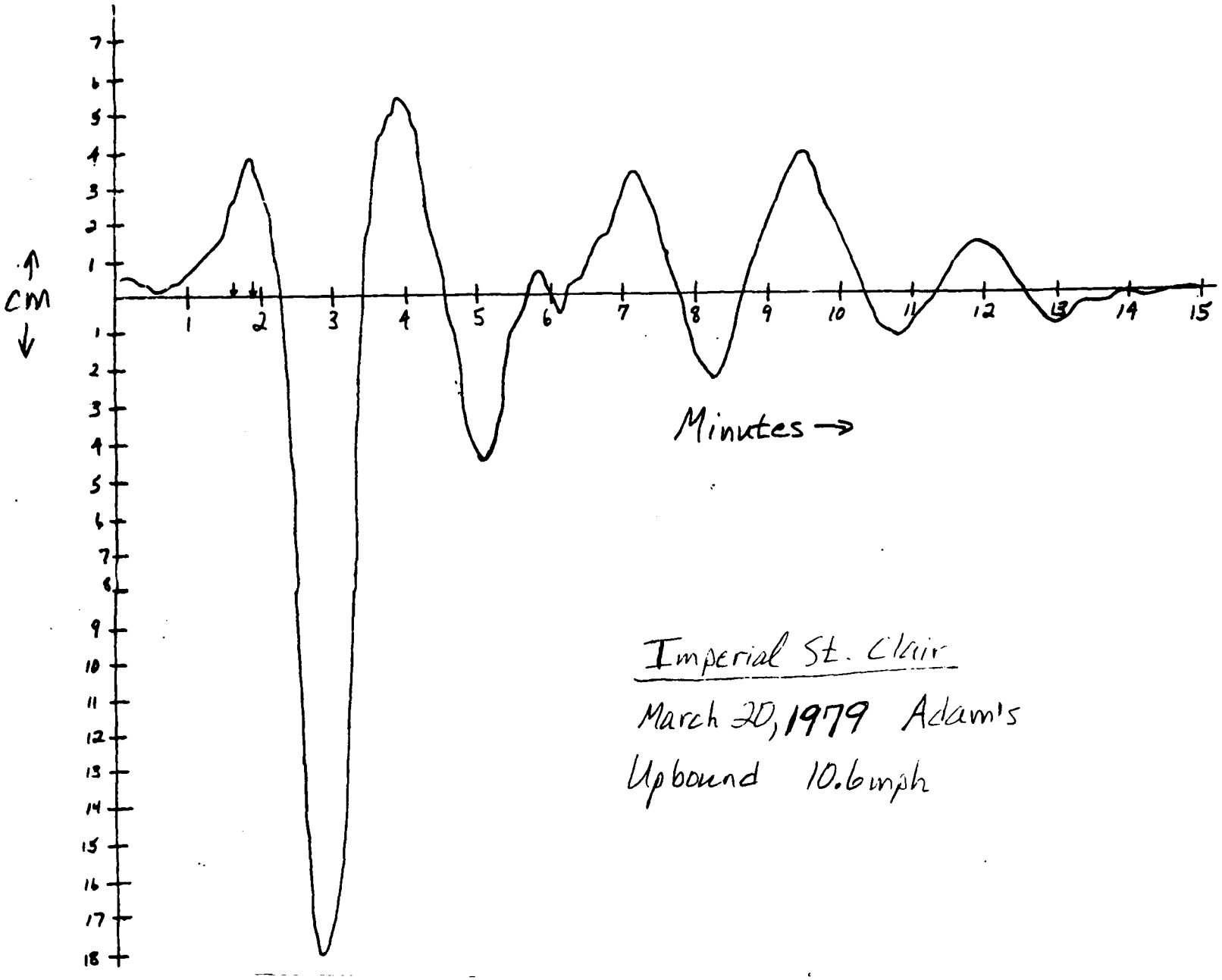
Adam's station 10.6 mph

16 + 8 cm samplers used – no sample obtained

– Red arrows indicate time of vessel passage in front of station.



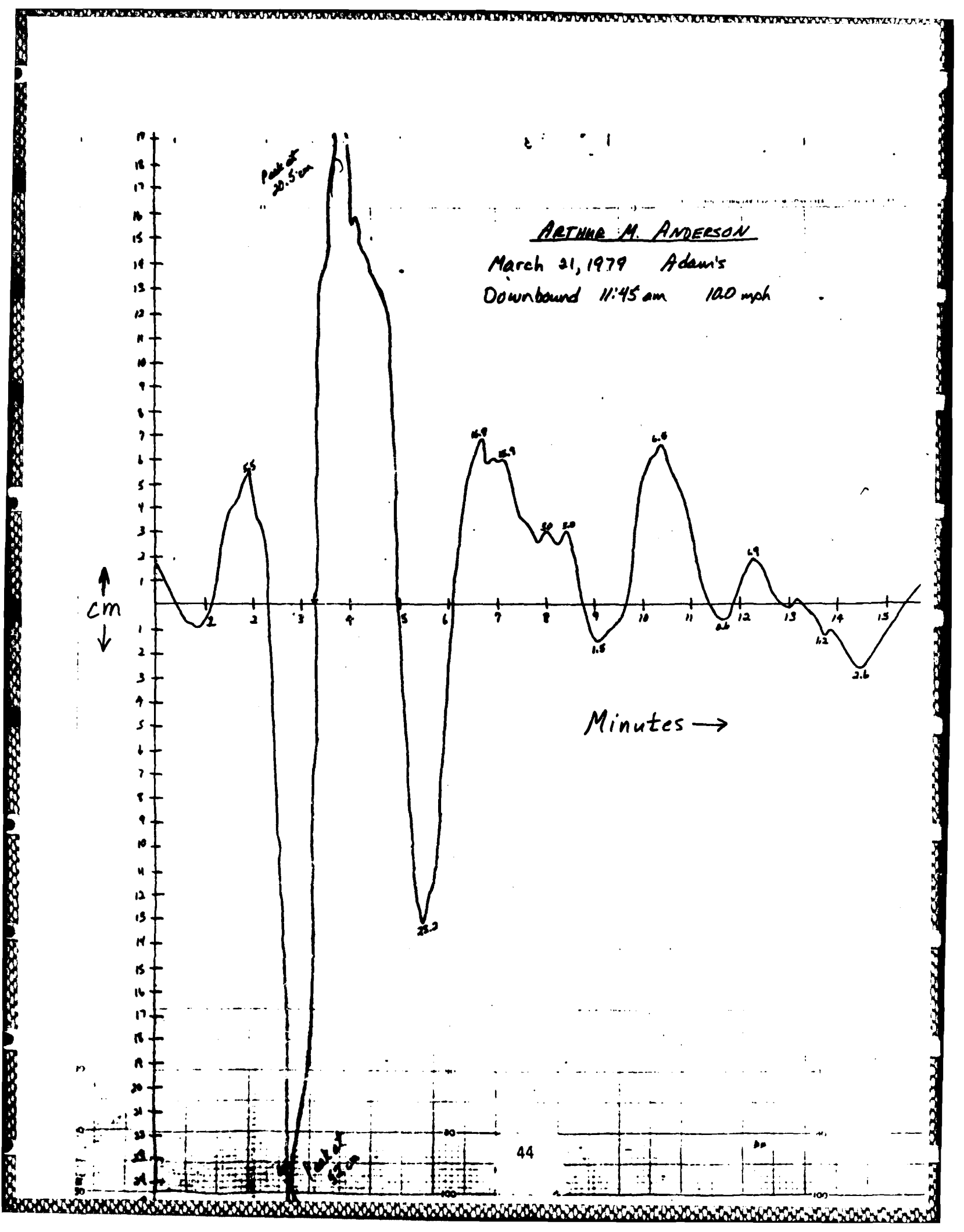
- Red arrows indicate time of vessel passage in front of station.

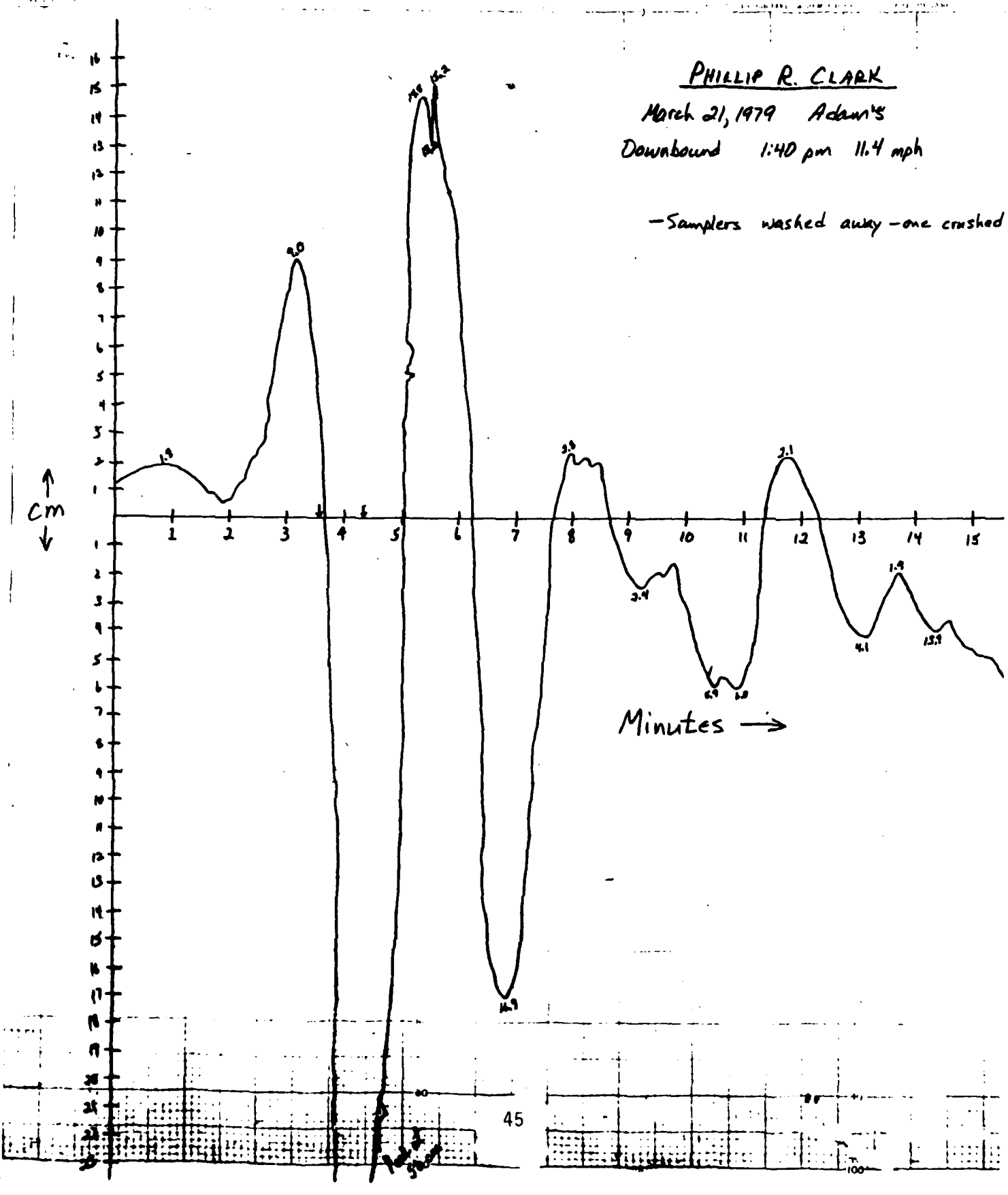


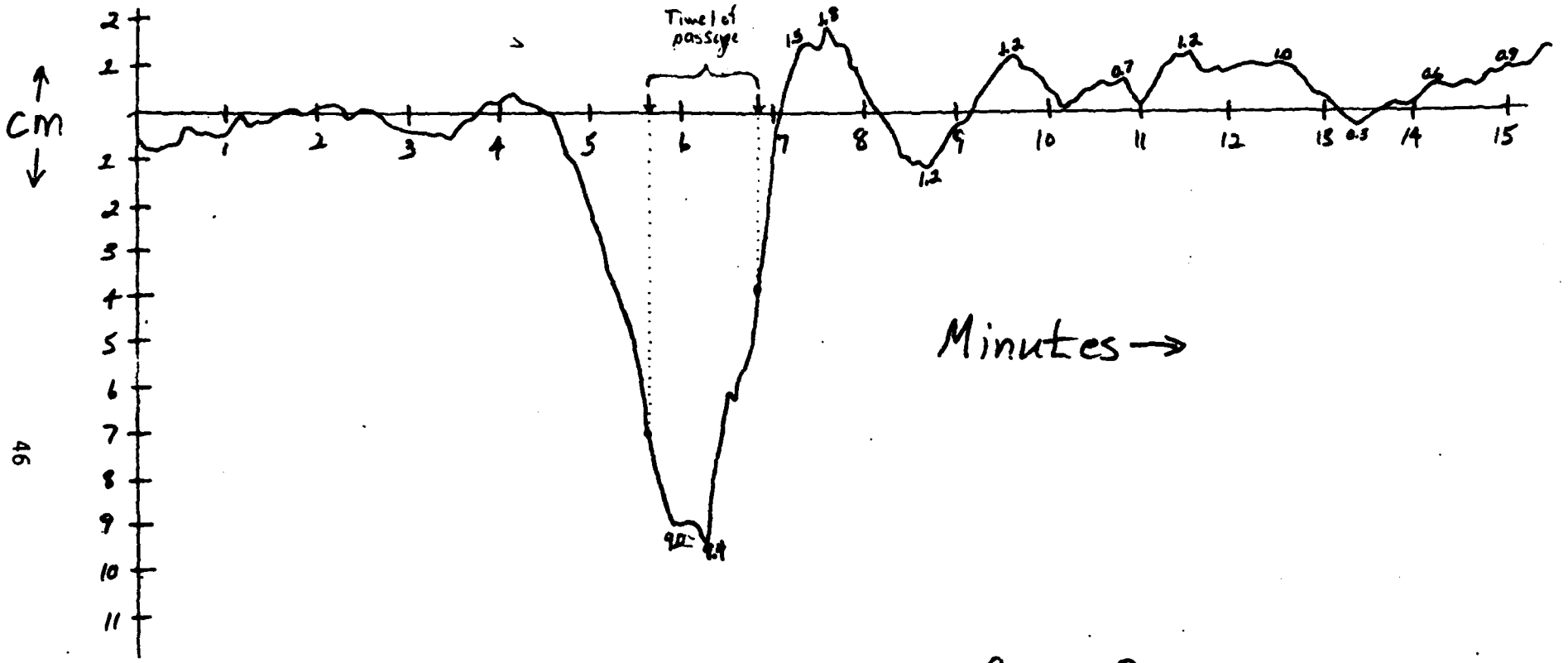
Imperial St. Clair

March 20, 1979 Adam's

Upbound 10.6 mph


ARTHUR M. ANDERSON
March 21, 1979 Adam's
Downbound 11:45 am 10.0 mph
cm
Minutes →


PHILLIP R. CLARK
March 21, 1979 Adam's
Downbound 1:40 pm 11.4 mph
-Samplers washed away - one crushed
cm
Minutes →

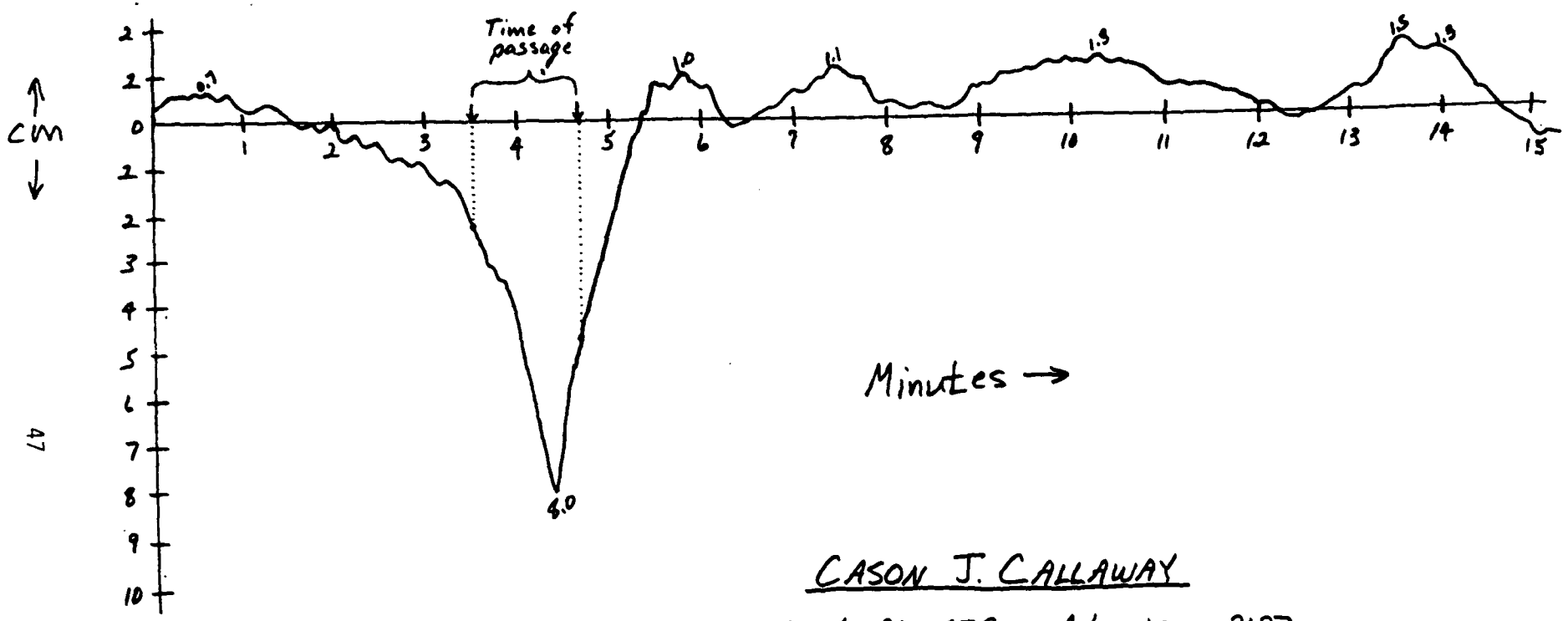


ROGER BLOUGH

March 26, 1979 Adam's

Down bound 7.3 mph 1:48 pm

10 cm sampler used - no sample obtaine



47

CASON J. CALLAWAY

March 26, 1979 Adam's 2:27pm

Downbound 7.5 mph

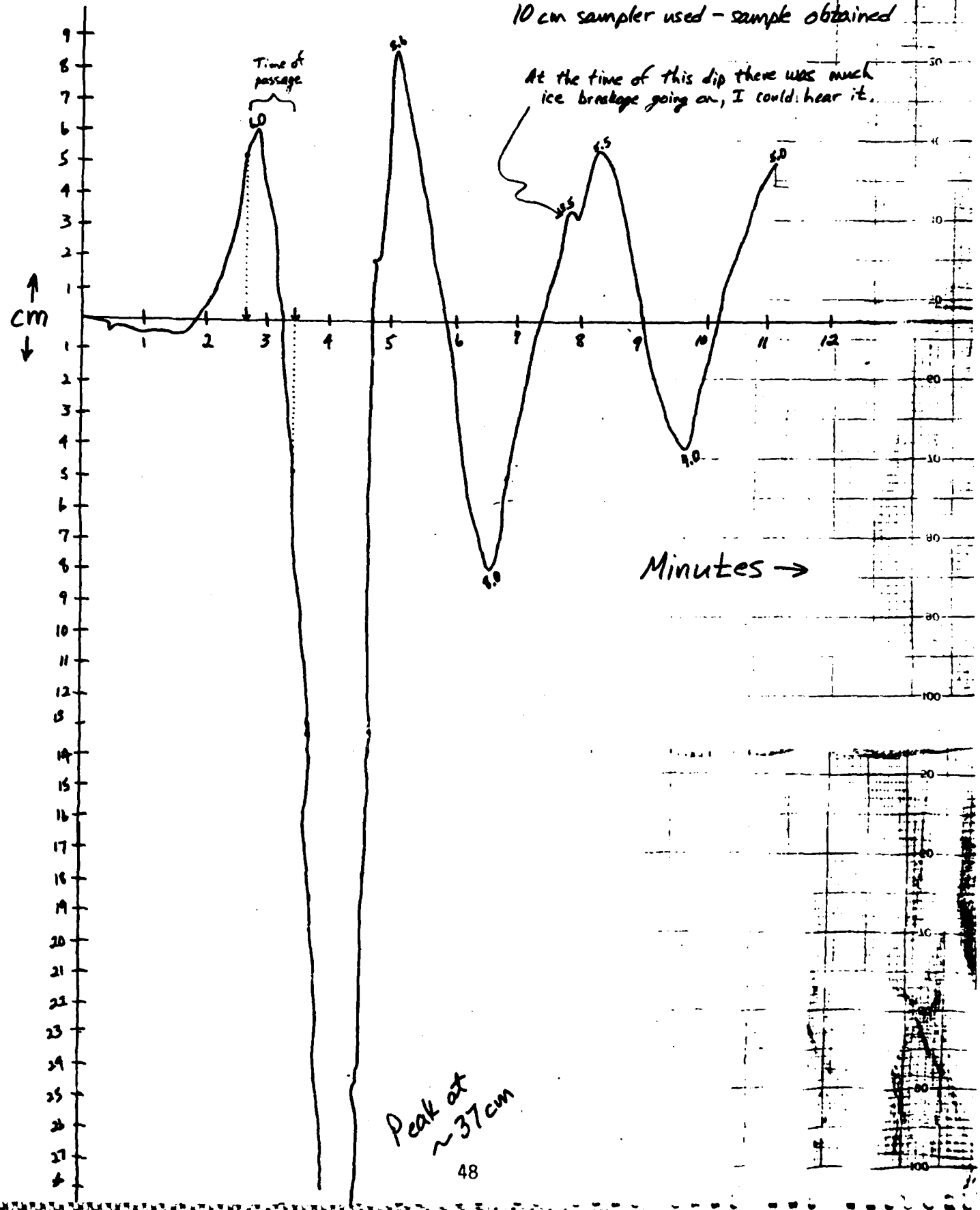
10 cm sampler used – no sample obtained

PHILLIP R. CLARK

March 27, 1979 Adam's 10:35 am

Upbound 11.5 mph

10 cm sampler used - sample obtained

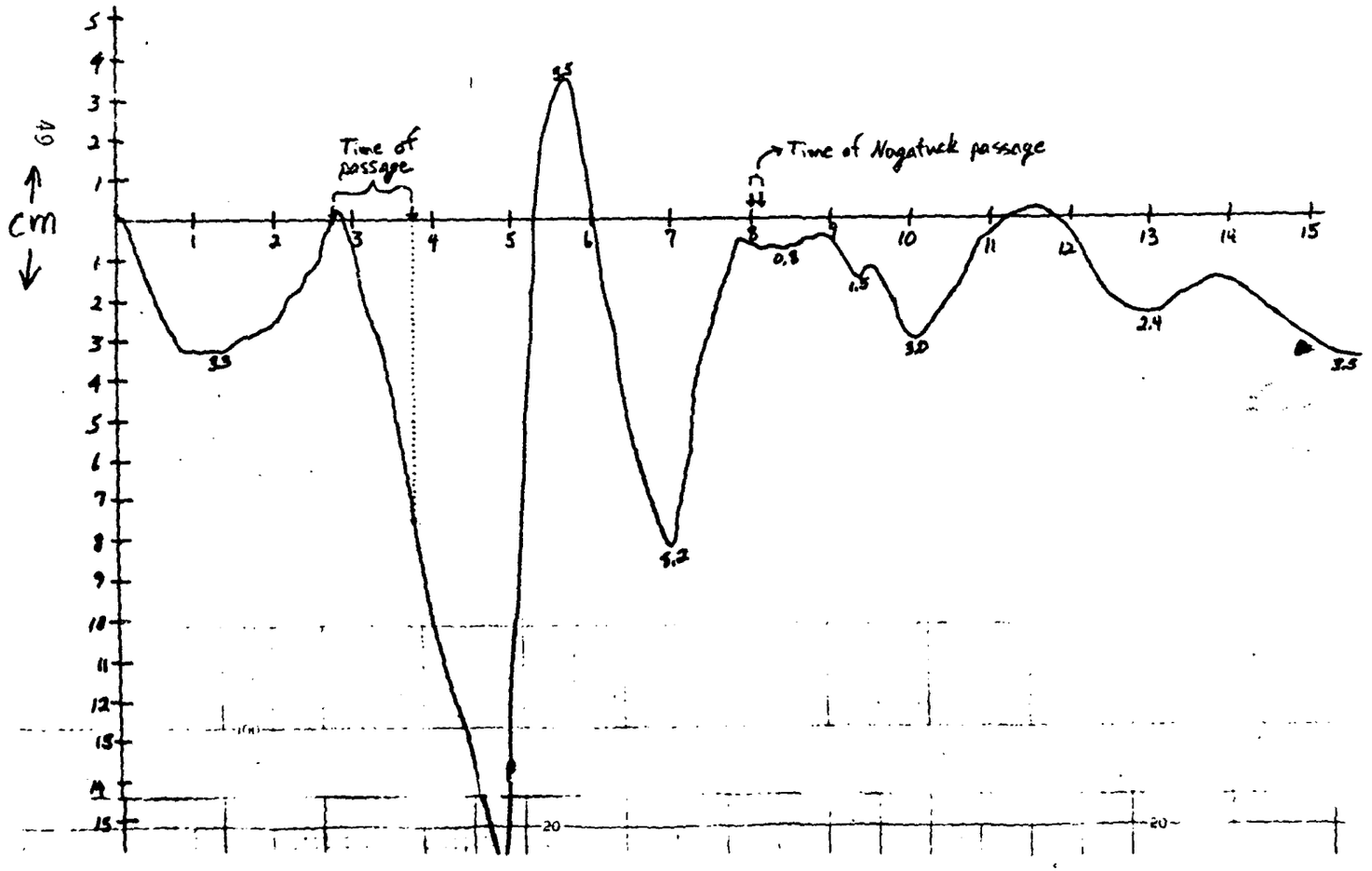


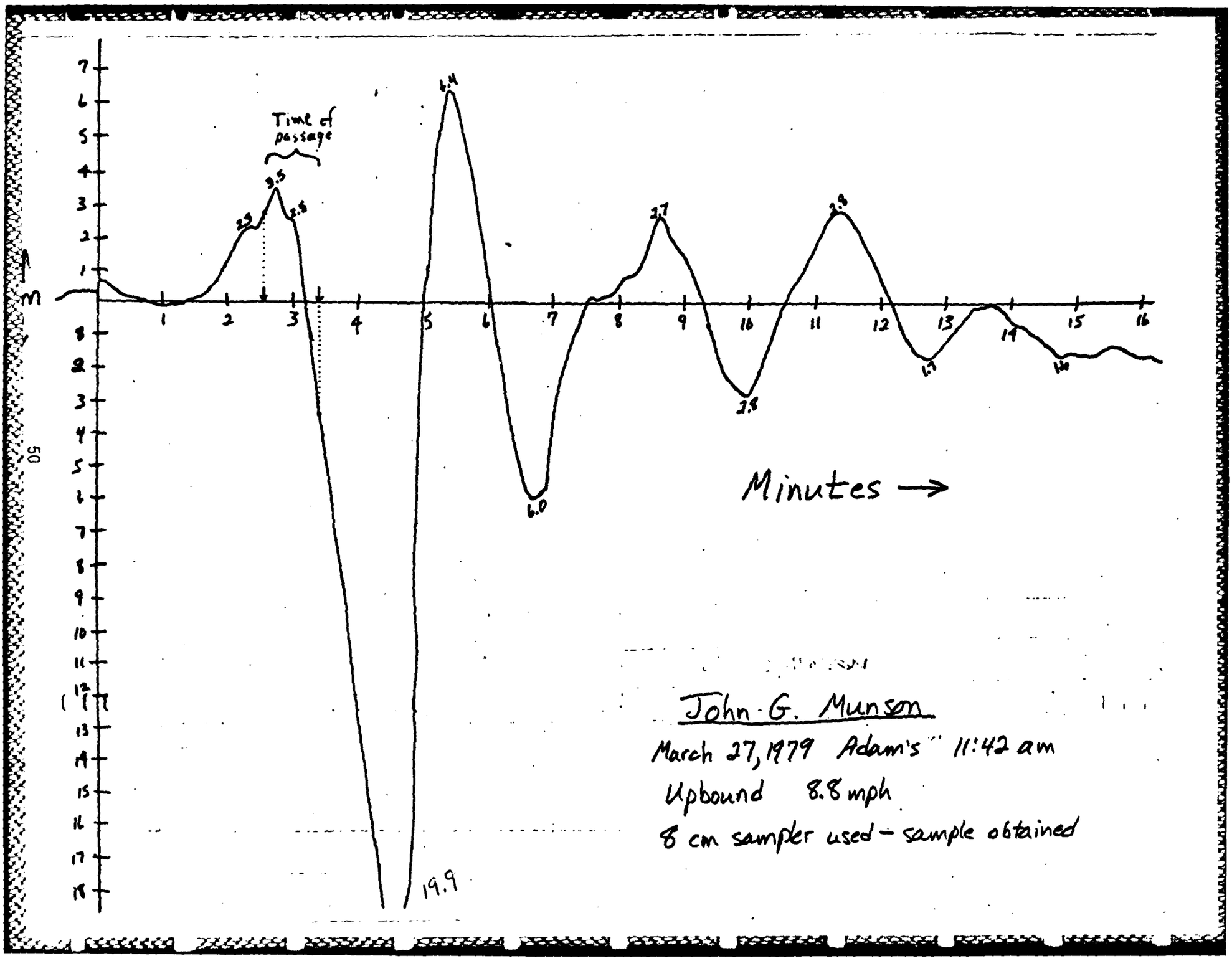
ARTHUR M. ANDERSON (+ Nogatuck)

March 27, 1979 Adam's 10:52 am

Upbound 7.2 mph

8 cm sampler used – no sample obtained





John G. Munson

March 27, 1979 Adam's 11:42 am

Upbound 8.8 mph

8 cm sampler used – sample obtained

Appendix B: BENTHIC BOTTOM SAMPLE DATA

RIVERVIEW MARINA

Sample 1, January 24, 1979

Description	Number	% of Sample
ANNELIDA: Oligochaeta	50	18.2
ANNELIDA: Hirudinea	1	0.4
AMPHIPODA: Gammaridae--*Gammarus sp.*	1	0.4
AMPHIPODA: Talitridae--*Hyalella sp.*	8	2.9
HYDRACARINA	7	2.5
EPHEMEROPTERA: Ephemeridae--*Ephemera sp.*	4	1.4
EPHEMEROPTERA: Ephemeridae--*Hexagenea sp.*	3	1.1
TRICHOPTERA: Limnephilidae	3	1.1
TRICHOPTERA: Rhyacophilidae	2	0.7
TRICHOPTERA: Leptoceridae--*Setodes sp.*	1	0.4
TRICHOPTERA: Leptoceridae--*Trianodes sp.*	2	0.7
DIPTERA: Chironomidae--Chironominae	4	1.4
DIPTERA: Chironomidae--Orthocladiinae	2	0.7
DIPTERA: Chironomidae--Tanypodinae	6	2.2
DIPTERA: Heleidae	4	1.4
GASTROPODA	149	54.2
PELECYPODA	28	10.2

TOTAL: 275 organisms

RIVERVIEW MARINA

Sample 2, January 24, 1979

Description	Number	% of Sample
NEMATODA	1	0.5
ANNELIDA: Oligochaeta	38	19.0
ANNELIDA: Polychaeta--*Manayunkia sp.*	1	0.5
ISOPODA	2	1.0
HYDRACARINA	5	2.5
EPHEMEROPTERA: Ephemeridae--*Ephemera sp.*	2	1.0
EPHEMEROPTERA: Ephemeridae--*Hexagenea sp.*	1	0.5
TRICHOPTERA: Leptoceridae--*Trianodes sp.*	1	0.5
DIPTERA: Chironomidae--Orthocladiinae	4	2.0
DIPTERA: Chironomidae--Tanypodinae	4	2.0
DIPTERA: Heleidae	2	1.0
GASTROPODA	111	55.5
PELECYPODA	28	14.0

TOTAL: 200 organisms

RIVERVIEW MARINA

Sample 3, January 24, 1979

Description	Number	% of Sample
ANNELIDA: Oligochaeta	81	28.3
ANNELIDA: Polychaeta--*Manayunkia sp.*	3	1.0
AMPHIPODA: Gammaridae--*Gammarus sp.*	2	0.7
AMPHIPODA: Talitridae--*Hyalella sp.*	9	3.1
HYDRACARINA	9	3.1
EPHEMEROPTERA: Caenidae	3	1.0
EPHEMEROPTERA: Ephemeridae--*Ephemera sp.*	1	0.3
EPHEMEROPTERA: Ephemeridae--*Hexagenea sp.*	1	0.3
TRICHOPTERA: Limnephilidae	1	0.3
TRICHOPTERA: Rhyacophilidae	4	1.4
TRICHOPTERA: Leptoceridae--*Trianodes sp.*	2	0.7
DIPTERA: Chironomidae--Chironominae	1	0.3
DIPTERA: Chironomidae--Orthocladiinae	22	7.7
DIPTERA: Chironomidae--Tanypodinae	12	4.2
DIPTERA: Heleidae	3	1.0
DIPTERA: Simulidae	1	0.3
GASTROPODA	108	37.8
PELECYPODA	24	8.4

TOTAL: 286 organisms

DORAN'S

Sample 1, January 25, 1979

Description	Number	% of Sample
NEMATODA	2	0.8
ANNELIDA: Oligochaeta	25	9.4
ANNELIDA: Polychaeta	2	0.8
AMPHIPODA: Gammaridae--*Gammarus sp.*	1	0.4
AMPHIPODA: Talitridae--*Hyalella sp.*	2	0.8
HYDRACARINA	5	1.9
TRICHOPTERA: Leptoceridae--*Setodes sp.*	1	0.4
TRICHOPTERA: Rhyacophilidae--*Wormaldia sp.*	1	0.4
DIPTERA: Chironomidae--Chironominae	20	7.5
DIPTERA: Chironomidae--Orthocladiinae	12	4.5
DIPTERA: Heleidae	10	3.7
GASTROPODA	161	60.3
PELECYPODA	25	9.4

TOTAL: 267 organisms

DORAN'S

Sample 2, January 25, 1979

Description	Number	% of Sample
ANNELIDA: Oligochaeta	27	9.5
ISOPODA	1	0.4
AMPHIPODA: Gammaridae--*Gammarus sp.*	2	0.7
AMPHIPODA: Talitridae--*Hyalella sp.*	11	3.9
HYDRACARINA	7	2.5
EPHEMEROPTERA: Caenidae	1	0.4
EPHEMEROPTERA: Ephemeridae--*Hexagenea sp.*	1	0.4
TRICHOPTERA: Leptoceridae--*Setodes sp.*	2	0.7
TRICHOPTERA: Leptoceridae--*Trianodes sp.*	1	0.4
DIPTERA: Chironomidae--Chironominae	21	7.4
DIPTERA: Chironomidae--Orthocladiinae	11	3.9
DIPTERA: Chironomidae--Tanypodinae	17	6.0
DIPTERA: Heleidae	8	2.8
GASTROPODA	153	54.1
PELECYPODA	21	7.1

TOTAL: 283 organisms

DORAN'S

Sample 3, January 25, 1979

Description	Number	% of Sample
ANNELIDA: Oligochaeta	33	11.6
ANNELIDA: Polychaeta	4	1.4
ANNELIDA: Hirudinea	2	0.7
AMPHIPODA: Talitridae--*Hyalella sp.*	4	1.4
HYDRACARINA	3	1.0
MEGALOPTERA: Sialidae--*Sialis sp.*	1	0.4
TRICHOPTERA: Leptoceridae--*Setodes sp.*	1	0.4
TRICHOPTERA: Rhyacophilidae	1	0.4
DIPTERA: Chironomidae--Chironominae	16	5.6
DIPTERA: Chironomidae--Orthocladiinae	17	6.0
DIPTERA: Chironomidae--Tanypodinae	12	4.2
DIPTERA: Heleidae	4	1.4
GASTROPODA	168	58.9
PELECYPODA	19	6.7

TOTAL: 285 organisms

ADAM'S

Sample 1, February 15, 1979

Description	Number	% of Sample
NEMATODA	1	0.4
ANNELIDA: Oligochaeta	26	10.6
ISOPODA	5	2.0
AMPHIPODA: Talitridae--*Hyalella sp.*	2	0.8
HYDRACARINA	2	0.8
EPHEMEROPTERA: Ephemeridae--*Hexagenea sp.*	2	0.8
TRICHOPTERA: Leptoceridae--*Setodes sp.*	2	0.8
TRICHOPTERA: Limnephilidae	2	0.8
TRICHOPTERA: Rhyacophilidae	1	0.4
DIPTERA: Chironomidae--Chironominae	68	27.8
DIPTERA: Chironomidae--Orthocladiinae	18	7.3
DIPTERA: Heleidae	14	5.7
GASTROPODA	75	30.6
PELECYPODA	27	11.0

TOTAL: 245 organisms

ADAM'S

Sample 2, February 15, 1979

Description	Number	% of Sample
ANNELIDA: Oligochaeta	25	22.3
ISOPODA	1	0.9
EPHEMEROPTERA: Ephemeridae--*Hexagenea sp.*	2	1.8
TRICHOPTERA: Leptoceridae--*Setodes sp.*	1	0.9
DIPTERA: Chironomidae--Chironominae	1	0.9
DIPTERA: Chironomidae--Orthocladiinae	9	8.0
DIPTERA: Chironomidae--Tanypodinae	4	3.6
DIPTERA: *Heleidae*	5	4.5
GASTROPODA	32	28.6
PELECYPODA	32	28.6

TOTAL: 112 organisms

ADAM'S

Sample 3, February 15, 1979

Description	Number	% of Sample
NEMATODA	3	5.4
ANNELIDA: Oligochaeta	13	23.6
ISOPODA	1	1.8
EPHEMEROPTERA: Ephemeridae--*Ephemera sp.*	1	1.8
EPHEMEROPTERA: Ephemeridae--*Hexagenea sp.*	1	1.8
TRICHOPTERA: Rhyacophilidae	1	1.8
DIPTERA: Chironomidae--Orthocladiinae	7	12.7
DIPTERA: Chironomidae--Tanypodinae	2	3.6
DIPTERA: Heleidae	3	5.4
GASTROPODA	14	25.4
PELECYPODA	9	16.4

TOTAL: 55 organisms

Appendix C: ALGAL DISTRIBUTION
BY SAMPLE

Genera	Riverview			Doran's			Adam's		
	1	2	3	1	2	3	1	2	3
Ulothrix sp.	x	x		x	x		x		x
Microspora sp.								x	
Rhizoclonium sp.								x	
Debarya sp.							x		
Nitella sp.		x	x			x			
Characiopsis sp.							x		
Tabellaria sp.	x				x			x	x
Fragilaria sp.			x						x
Rhoicosphenia sp.		x			x		x		x
Stauroneis sp.							x		
Gomphoneis sp.			x	x			x		
Cymbella sp.	x	x	x	x		x		x	x
Campylodiscus sp.								x	
Oscilliatora sp.								x	

Date	Location	Vessel Description	(cm) Sampler Size	% Water	% Benthos	% Other
		400-700 Ft. (118.5-207.4 m)				
		5-10 mph (8-16 kph)				
3/27/79	Adam's	Arthur M. Anderson	8	0.00	0.00	0.00
3/27/79	Adam's	John G. Munson	8	99.86	0.00	.14
3/07/79	Doran's	Imperial St. Clair	16	99.90	0.00	.10
3/07/79	Doran's	Imperial St. Clair	8	99.94	0.00	.06
3/08/79	Doran's	Imperial St. Clair	8	0.00	0.00	0.00
3/08/79	Doran's	Imperial St. Clair	16	0.00	0.00	0.00
3/14/79	Adam's	Imperial St. Clair	16	99.83	0.00	.17
3/21/79	Adam's	Arthur M. Anderson	8	0.00	0.00	0.00
3/21/79	Adam's	Arthur M. Anderson	16	0.00	0.00	0.00
		Over 10 mph (16 kph)				
3/20/79	Adam's	Imperial St. Clair	8	0.00	0.00	0.00
3/20/79	Adam's	Imperial St. Clair	16	0.00	0.00	0.00
		700-1000 Ft. (207.4-296.3 m)				
		5-10 mph (8-16 kph)				
2/16/79	Doran's	Phillip R. Clark	16*	99.98	.02	0.00
3/18/79	Adam's	Roger Blough	8	99.83	.03	.14
3/18/79	Doran's	Roger Blough	10	99.82	.07	.11
3/18/79	Adam's	Roger Blough	16	99.99	0.00	.01
3/26/79	Adam's	Cason J. Callaway	10	0.00	0.00	0.00
3/26/79	Adam's	Roger Blough	10	0.00	0.00	0.00
		Over 10 mph (16 kph)				
3/21/79	Adam's	Phillip R. Clark	8	99.37	.30	.33
3/21/79	Adam's	Phillip R. Clark	16	99.89	.07	.04
3/27/79	Adam's	Phillip R. Clark	10	99.87	0.00	.13

* Was first attempted sampler and was found to be ineffective for large volumes. Replaced later with described sampling apparatus.

Appendix E: KYMOGRAPH RECORDINGS LOG

Date	Location	Vessel Name	(mph) Speed	Direction
1-26	Riverview	Enders M. Voorhees	8.9	Upbound
1-26	Riverview	Katamai Bay	11.2	Upbound
1-29	Doran's	C. G. Cutter Mackinaw	7.0	Upbound
1-29	Doran's	Cason J. Callaway	11.0	Downbound
1-29	Doran's	Presque Isle	5.3	Downbound
1-30	Doran's	Hudson Transport	4.9	Downbound
1-30	Doran's	Doan Transport	7.8	Upbound
2-5	Doran's	Leon Fraser	8.6	Downbound
2-16	Doran's	C. G. Cutter Mackinaw	7.2	Upbound
2-16	Doran's	Phillip R. Clark	8.2	Upbound
2-16	Doran's	Cason J. Callaway	8.3	Upbound
2-16	Doran's	John G. Munson	8.0	Upbound
2-19	Doran's	Edwin H. Gott	4.5	Upbound
3-7	Doran's	Imperial St. Clair	9.7	Upbound
3-8	Doran's	Imperial St. Clair	9.7	Downbound
3-14	Adam's	Imperial St. Clair	6.3	Upbound
3-20	Adam's	Imperial St. Clair	10.6	Upbound
3-21	Adam's	Arthur M. Anderson	10.0	Downbound
3-21	Adam's	Phillip R. Clark	11.4	Downbound
3-26	Adam's	Roger Blough	7.3	Downbound
3-26	Adam's	Cason J. Callaway	7.5	Downbound
3-27	Adam's	Phillip R. Clark	11.5	Upbound
3-27	Adam's	Arthur M. Anderson	7.2	Upbound
3-27	Adam's	John G. Munson	8.8	Upbound

APPENDIX F
VESSEL BEAM, DRAFT & RELATIVE VELOCITY
vs.
VOLUME DISPLACED

DATE	VESSEL	DIRECTION	(mph) RELATIVE VELOCITY*	(ft.) BEAM	(ft.) DRAFT	(mi) VOLUME DISPLACED	(cm) SAMPLER SIZE**
2-16	Phillip R. Clark	Upbound	8.9	70	22	12,000	16
3-7	Imperial St. Clair	Upbound	10.4	74	20	15,300	8
3-7	Imperial St. Clair	Upbound	10.4	74	20	7,400	8
3-14	Imperial St. Clair	Upbound	7.0	74	24	350	16
3-18	Roger Blough	Upbound	16.0	105	24	5,790	10
3-18	Roger Blough	Upbound	16.0	105	24	1,625	16
3-18	Roger Blough	Upbound	16.0	105	24	6,300	8
3-21	Phillip R. Clark	Downbound	10.7	70	25.5	400	16
3-21	Phillip R. Clark	Downbound	10.7	70	25.5	2,000	8
3-27	John G. Munson	Upbound	9.5	72	20	70	8
3-27	Phillip R. Clark	Upbound	12.2	70	21.5	75	10

*Relative Velocity = shore speed + current factor of .72 mph.

**Sampler size refers to the 3 mouth width sizes of the samplers used (i.e. 8, 10 and 16 cm wide). For clearer description see Methodology section of text, page 3.

Appendix G: CRACK SAMPLE LOG AND PERCENT TRANSMITTANCE

DATE	LOCATION	VESSEL	DIRECTION	(cm) SAMPLER SIZE	(ml) VOLUME DISPLACED	(JTU) PERCENT TRANSMITTANCE
2-16	Doran's	Phillip R. Clark	Upbound	16	12,000	—
3-7	Doran's	Imperial St. Clair	Upbound	16	15,300	92
3-7	Doran's	Imperial St. Clair	Upbound	8	7,400	94
3-8	Doran's	Imperial St. Clair	Downbound	16	-0-	—
3-8	Doran's	Imperial St. Clair	Downbound	8	-0-	—
3-14	Adam's	Imperial St. Clair	Upbound	16	350	95
3-18	Doran's	Roger Blough	Upbound	10	5,790	89
3-18	Adam's	Roger Blough	Upbound	16	1,625	96
3-18	Adam's	Roger Blough	Upbound	8	6,300	96.5
3-20	Adam's	Imperial St. Clair	Upbound	16	-0-	—
3-20	Adam's	Imperial St. Clair	Upbound	8	-0-	—
3-21	Adam's	Arthur M. Anderson	Downbound	16	-0-	—
3-21	Adam's	Arthur M. Anderson	Downbound	8	-0-	—
3-21	Adam's	Phillip R. Clark	Downbound	16	400	88
3-21	Adam's	Phillip R. Clark	Downbound	8	2,000	81
3-26	Adam's	Roger R. Blough	Downbound	10	-0-	—
3-26	Adam's	Cason J. Callaway	Downbound	10	-0-	—
3-27	Adam's	Phillip R. Clark	Upbound	10	75	79
3-27	Adam's	Arthur M. Anderson	Upbound	8	-0-	—
3-27	Adam's	John G. Munson	Upbound	8	70	73

END

DATE

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